*Boston, May 1st, 1824.*

THE

# BOSTON JOURNAL

OF

## Philosophy and the Arts,

CONTAINING Selections from the Transactions of Learned Societies and foreign Scientific Journals, and original analytical views of subjects in Philosophy and the Arts compiled from various sources; intended to exhibit a view of the progress of discovery in Natural Philosophy, Mechanics, Chemistry, Geology and Mineralogy, Natural History, Comparative Anatomy and Physiology, Geography, Statistics, and the Fine and useful Arts. Conducted by JOHN W. WEBSTER, M. D. JOHN WARE, M. D. and DANIEL TREADWELL, Fellows of the American Academy of Arts and Sciences.

*Published by Cummings, Hilliard & Co. No. 1, Cornhill, Boston; to whom communications are to be addressed, post-paid.*

THE object of this work is to render accessible to the American public, the various and important information which is constantly communicated to the European world, through the transactions of their learned Societies, and their

Scientific Journals. It is well known that nearly all the valuable discoveries in Philosophy, of the present century, have been first made known through these publications. Their number has now, however, become so extended, that access to them can be obtained by only a small proportion of readers. This is particularly the case in our own country, and a veil is thus drawn between us and the rapid progress which is daily making in discovery on the other side of the Atlantic. It is also to be considered that as they have increased in number, their value has been somewhat diminished by the frequent admission of indifferent articles.

It is intended in the work, the plan of which is now submitted to the public, to publish selections of such papers, or parts of papers, as are in themselves most valuable, or possess an interest from any relation they may have to the situation and prospects of the American people,—to make occasional abridgments of those whose length would preclude their admission entire,—and whenever there may happen to be a variety of articles from different sources upon any particular subject, to present analytical views of them. This last method of communicating information it is hoped may be made especially useful; since it happens, that observations relating to the same subject are frequently made at nearly the same time, by several individuals in different parts of the world, all of which it would be impossible to publish, whilst yet an analytical view of the whole would be of great value.

It may be added, that although the principal object will be the publication of selections from foreign works; yet, it is not intended that the pages of this Journal shall be closed against any original articles of merit which may be offered, particularly those relating to the history and progress of discovery in our own country.

## Conditions.

**This Work is published on good paper, and with a new type. A number, containing one hundred pages, is issued every two months. Price four dollars a year, payable on the delivery of the third Number of each volume.**

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# PHILOSOPHY AND THE ARTS,

EXHIBITING A VIEW OF

THE PROGRESS OF DISCOVERY IN NATURAL PHILOSOPHY, MECHANICS, CHEMISTRY, GEOLOGY, AND MINERALOGY ; NATURAL HISTORY, COMPARATIVE ANATOMY, AND PHYSIOLOGY ; GEOGRAPHY, STATISTICS, AND THE FINE AND USEFUL ARTS.

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# PREFACE.

Having brought the first volume of this Journal to a conclusion, the Editors take this opportunity again to call the attention of the public to their undertaking. They are more than ever convinced of the importance of their plan and of the extent to which, if properly conducted, it is capable of being made useful. The scientific labours of European philosophers are made known to the world from so many different quarters, their productions are spread over so wide a surface, are scattered among so great a number of Journals and volumes of Transactions, and the valuable are so connected and mingled with the worthless, that it is very difficult for individuals in America, except under uncommon advantages, to get a complete view of the progress of science and the arts. The expense of importation is so great that few persons can consistently afford to procure for their own use even one of the foreign Journals. It is only in public libraries, Atheneums, &c. that complete series of them are to be looked for, and it is unnecessary to say, how small a proportion of the reading population have either leisure or opportunity to avail themselves of establishments of this nature.

The principal object of the Editors has been to present in their publication, whatever was useful or interesting among the contents of the European periodical works, either in the language of the authors themselves, or in a more condensed and abridged form in their own. But as they have wished to make it as complete a record as possible of the state of science in America as well as in Europe, they have by no means confined themselves to selections from foreign works. The pages of this volume will be found to contain a very considerable num-

ber of original articles, relating principally to American science. In fact, the quantity of matter expressly written for this Journal, either original or compiled, is very little less, in proportion than is contained in most of the European Journals of Science.

The limited means which the Editors felt themselves authorized to risk upon this undertaking and the uncertainty of the degree of support they should meet with, have prevented them from procuring so abundant and prompt a supply of European publications as they wished. The embarrassment they have laboured under in this particular has been considerable, and they are confident that their Journal is capable of being made far more valuable than it has been, should public patronage be sufficient to enable them to devote the necessary funds to this object.

The patronage they have received in this immediate neighbourhood, has been flattering, and has been of itself nearly sufficient to meet the necessary expenses of the work. But at a distance, little progress has been made—the subscription has advanced slowly, if at all, and without a more extensive support, it is impossible that the work should become so interesting or so useful, as it is capable of being made. While, therefore, it is their intention, at all events, to proceed with a second volume of the Journal, they solicit the attention and patronage of their countrymen in order that they may be enabled to make it more worthy of public favour and more deserving of encouragement.

*Boston, May 1st,* 1824.

THE

# Boston Journal

OF

# PHILOSOPHY AND THE ARTS.

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**Art. I.**—*Remarks on the Increase of the Population of the United States, and Territories of North America, with Original Tables deduced from the American Population Returns, to illustrate the various rates of Increase in the White Population and Slaves, and also the comparative degrees in which Agriculture, Commerce, and Manufactures prevail.* By George Harvey, Esq. Member of the Astronomical Society. Communicated by the Author. [*Edin. Phil. Jour.*]

The following paper owes its origin to a desire of inquiring into the growth and progressive augmentation of the population of the United States, and territories of North America. The subject is important, and connected as it is with so many other interesting objects of investigation, it cannot but have awakened the curiosity and attention of every one engaged in the cultivation of statistical science. In England, and perhaps in most other European countries, it is difficult to form a perfect estimate of the causes which have contributed to the rapid increase of the American population, and to the successful advancement of the different states and territories of that portion of the globe, in arts, manufactures and commerce; and it was principally with the hope of obtaining more correct information from some of the active and enlightened philosophers on the other side of the Atlantic, who, from their habits of personal observation, are so well qualified to throw a light on the imperfect elements, with

which we at present happen to be furnished, that this essay is now submitted to the readers of the Edinburgh Journal.

The object, which it is hoped has been kept steadily in view in the composition of this paper, has been to admit no other principle or conclusion, than what a careful analysis of the population returns of America would afford; and to endeavour to trace through all its states and territories, the degrees in which their diversified rates of increase have prevailed; and, by examining the various ages, and following all the shades and varieties which their different increments and decrements afford; and comparing, as far as circumstances will allow, the situation of the sexes, in their opposite states of slavery and freedom;—to form some estimate of the actual condition of the American population, as far, at least, as statistical tables, like those under review, are capable of affording.

In order to place the subject in a clear point of view, I have found it necessary to compute several tables, which will be introduced in their proper places. The sources from which these have been derived, are the "Tables of the American Census," contained in Godwin's "Enquiry concerning Population," and which that author obtained from "Pitkin's Statistical View of the United States;" and an account of the census for 1820, contained on a single sheet, kindly furnished me by my friend and townsman, Mr Wills.

Before entering on an analysis of these tables, it may not be uninteresting to offer a few remarks respecting the different surveys which have been taken of the population of the United States.

The first authorized census took place in August 1790, the returns for which, when contrasted with those lately published as the result of the census of 1820, will not only furnish the most evident proofs of the rapid increase of the American population, but also of the advancement which has been made by the government of that country, in enlarged and proper views of the objects of statistical science. Previous to the year 1790, no information existed respecting the precise amount of the American population. In 1731 it was supposed, by Dr Franklin, to amount to a million; and Mr Pitkin estimates it at 1,046,000, for the year 1749. If these accounts can be relied on, it would seem as if little or no increase was made in the population during eighteen years; a supposition certainly not to be reconciled with the rapid increments which succeeding years have disclosed.

In the census of 1790, the inhabitants were divided into the following classes, viz.

*First*, Free white males under sixteen years of age.
*Secondly*, Free white males of sixteen years, and upwards.
*Thirdly*, Free white females of all ages.
*Fourthly*, All other free persons.
*Fifthly*, Male and female slaves.

The result of this census gave a total population of 3,929,326.

The next census took place in 1800, when several important improvements were introduced. The free white males and females were each divided into the five following classes, viz.

*First*, All those under ten years of age.
*Secondly*, All those of ten, and under sixteen.
*Thirdly*, All those of sixteen, and under twenty-six, including heads of families.
*Fourthly*, All those of twenty-six, and under forty-five, including heads of families.
*Fifthly*, All those of forty-five, and upwards, including heads of families.

This division of the ages, although not embracing all the objects of a perfect statistical table, must still be regarded as a great improvement on the objects of the former census; and it was a considerable step, considering the slow march of information on these subjects, at once to divide both males and females into five classes, when, in the census of 1790, the former sex was divided only into two classes, and the latter was taken in one mass, without any distinction of age. This was an advantage, because it enabled statistical inquirers to estimate the increments which each sex had received, in the different periods of existence afforded by the classification, and thus to institute a comparison with other surveys of a like kind. The classes in the census of 1790, relating to "other free persons," and to "slaves," remained unaltered. The result of this census gave a total population of 5,309,758 persons.

In the year 1810 another census took place; but the classes into which the people were divided, and also the different subordinate divisions, remained the same as in 1800. The result gave a total population of 7,239,903.

In the census of 1820, however, the elements of some very important branches of statistical science were introduced; and the survey assumed a much more interesting and scientific form than either of the preceding. In the first place, the five classes, into which the free white males and females, were divided in the enumerations for 1800 and 1810, were preserved; but the free white males, between sixteen and eighteen, were selected from the class which embraced the males from

sixteen to twenty-six, and placed in a separate column. This, it may be presumed, was done for the purpose of shewing the power which the country possessed, in this very important class of persons; consisting, as it does, of young men in the prime of youth, and ready for the service of the state in almost every form.

That unfortunate part of the American community, the slaves, which in the former enumerations had been thrown into one mass, without any distinction of age or sex; in this census were divided into classes, embracing both these particulars. Each sex was separated into four classes, of the following ages:

*First*, All those under fourteen years of age.
*Secondly*, All those of fourteen, and under twenty-six.
*Thirdly*, All those of twenty-six, and under forty-five.
*Fourthly*, All those of forty-five and upwards.

The classes relating to the ages of the slave population, it is to be regretted, do not correspond with those of the free population; but they agree with another numerous class of persons in the United States, called "free coloured persons," the divisions of whose ages correspond with those of the slaves.

Another interesting and valuable addition to this census, is an account of the number of persons engaged in agriculture, commerce and manufactures, in each state and territory, and from which many interesting particulars may be deduced, respecting the comparative wealth, commercial activity, and internal resources of the different provinces. These additions to the objects embraced in the antecedent surveys, give room to hope, that succeeding enumerations of the American people will still better fulfil the objects which the cultivators of statistics have in view. Much remains yet to be done respecting the classification of the ages, and the introduction of such particulars as are calculated, from their nature, to throw a light on the great objects of the science. It is difficult, indeed, to conceive, to what cause the present division of the ages owe their origin. They certainly do not accord with such a classification, as an enlightened philosophy would suggest. The divisions ought at least to have been into classes of tens, above twenty years of age, and into classes of fives below the same age. Such a classification would have afforded the elements of much important information. If, indeed, the divisions could have been made into classes of fives, from a period of birth to the close of life, similar to the enlightened and philosophic divisions employed in Sweden, some

comparison might with safety have been made, between the increase of the inhabitants of the New World, and the authentic returns of a country, which has for so long a period nursed and fostered its population.

Great advantages result to mankind from inquiries of this kind. They admit of a practical application to many of their wants; and to the philosopher they afford the only perfect means of tracing with accuracy and precision, the important questions connected with the doctrine of population. It is pleasing to witness the growing intelligence which now pervades even the lowest classes of the community, with respect to this interesting subject*. A spirit of inquiry has been awakened, and the clouds of prejudice and error, which formerly enveloped almost every step of its course, begin to disappear. Not only for the interests of science, but for the benefit of mankind in general, it is to be hoped, that the elements of a perfect system of statistics will be gradually introduced, not only into the United States, but also throughout Europe; that more just and enlightened notions may be entertained respecting the laws which influence population; that the inhabitants, the arts, manufactures and commerce, of different countries, may be more readily compared with each other; and that a liberal and comprehensive policy may arise, embracing, in one grand and magnificent system, all the civilized nations of the earth.

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* Of the interest felt by all classes in the populous district of our island in which I reside, I had numerous opportunities of observing, during the time the census of 1821 was taking. The district to which I here allude is Plymouth. A few days prior to the time fixed for ascertaining the population, a number of gentlemen who were likely to feel an interest in the subject, were invited by the Mayor, at my suggestion, to attend a meeting, for the purpose of considering the propriety of assisting the overseers in ascertaining the population. The proposition was acceded to, and the town was divided into a number of small districts, and two gentlemen appointed to each. The public attention was called to the subject by a notice, explaining, in a clear and familiar manner, the nature of the measure, and pointing out the advantages that would particularly result to the lower classes, by enumerations of this kind, from their practical application to Benefit Societies, &c. The consequence of this appeal was, that the utmost readiness was displayed by *all ranks*, in furnishing the ages, the number of each sex, their employments, and such other particulars as the conditions of the census required. In a great many instances, these particulars were left on slips of paper by the heads of families with their servants, to prevent delay. The returns were most accurate and satisfactory, and proved the interest the people felt in the measure, when its nature was properly explained to them. I mention the circumstance here, because, at a future time, other towns may be induced to follow the example.

From the statements of Dr Franklin and Mr Pitkin, and the authorized population returns, the following rates of increase have been computed:

| | | Per Cent. |
|---|---|---|
| Increase of the whole Population from | 1731 to 1749, - - - | 4.6 |
| | 1749 to 1790, - - | 275.5 |
| | 1790 to 1800, - - - | 35.1 |
| | 1800 to 1810, - - | 36.1 |
| | 1810 to 1820, - - - | 32.9 |

The first and second rates of increase must be regarded as purely hypothetical; and I should consider, that either Dr Franklin or Mr Pitkin must have made a considerable error in the statement of the population. The rates of increase are so very discordant, that they cannot be by any means reconciled with each other. In eighteen years, for instance, the increment was only 4.6 per cent, whereas in forty-one years, it amounted to 275.5 per cent. The three last increments, therefore, are the only ones which can be relied on.

The following Table contains the results of the various rates of increase which the different states and territories have received since the census of 1790, and was computed from the returns of population before quoted. The first column embraces the names of the states and territories, and the succeeding columns the several rates of increase which these provinces have undergone, during the periods indicated at the head of the Table.

| States and Territories. | | Increase per cent from 1790 to 1800. | Increase per cent from 1800 to 1810. | Increase per cent from 1810 to 1820. |
|---|---|---|---|---|
| North. States. | Maine, - - - - | 57.2 | 50.7 | 30.4 |
| | New Hampshire, - | 29.6 | 16.6 | 13.9 |
| | Massachusetts, - - | 11.6 | 11.6 | 10.9 |
| | Rhode Island, - | 0.4 | 11.3 | 7.9 |
| | Connecticut, - - | 5.5 | 4.4 | 5.1 |
| | Vermont, - - | 80.6 | 41.1 | 8.2 |
| Middle States. | New York, - - | 72.3 | 63.6 | 32.7 |
| | New Jersey, - - | 14.7 | 16.3 | 13.0 |
| | Pennsylvania, - - | 38.7 | 34.4 | 29.5 |
| | Delaware, - - | 8.8 | 13.1 | 0.1 |
| | Ohio, - - - | 27.1 | 408.7 | 151.9 |
| | Indiana, - | — | 334.7 | 500.2 |

| | States and Territories. | Increase per cent from 1790 to 1800. | Increase per cent from 1800 to 1810. | Increase per cent from 1810 to 1820. |
|---|---|---|---|---|
| Southern States. | Maryland, - - | 10.7 | 7.5 | 7.0 |
| | Virginia, - - | 17.7 | 10.7 | 9.3 |
| | North Carolina, - | 21.4 | 16.2 | 15.0 |
| | South Carolina, - | 38.7 | 20.1 | 18.1 |
| | Georgia, - - - | 97.1 | 55.2 | 35.1 |
| | Louisiana, - - | — | — | 635.9 |
| | Tennessee, - - | — | 14.8 | 61.6 |
| | Kentucky, - - | 199.9 | 83.9 | 38.8 |
| Territorial Gov. | Alabama, - - | — | — | 67.1 |
| | Mississippi, - - | — | 35.6 | 87.0 |
| | Illinois, - - - | — | — | 349.5 |
| | Missouri, - - | — | — | — |
| | Michigan, - - | — | — | 86.8 |
| | Arkansas, - - | — | — | — |
| | Columbia, - - | — | 303.8 | 37.5 |

On reviewing the rates of increase exhibited in this Table, we cannot fail being struck by their singular diversity. In some the increment is feeble and unimportant, while in others it assumes a form remarkable for its magnitude. Their inequality also clearly proves, that the causes which have contributed to produce them, have not resulted from the operation of regular laws; and that they must have unquestionably arisen from those accidental causes, which a country influenced by immigration must be necessarily subject to. If we contrast, for example, the increments which the states of Vermont, New York, and Kentucky respectively received, in the periods from 1790 to 1800, and from 1810 to 1820, we shall perceive a striking inequality. Vermont, which, in the first of the periods alluded to, received an increment of 80.6 per cent, in the last received only 8.2. New York also, which, from 1790 to 1800, increased its population 72.3 per cent, in the period from 1810 to 1820 increased only at the rate of 32.7; and Kentucky, which, in the decade after the first census, augmented its population nearly 200 per cent, in the last ten years advanced only 38.8 per cent. In the state of Ohio also, the changes have been no less remarkable. In the first period it received an increment of 27.1 per cent; but, during the next ten years, this was augmented to 408.7, and in the ten years comprised between 1810 and 1820, it declined to 151.9 per cent. These unequal increments are indeed so numerous, that in the whole of the states and territories, two only can be found, namely, Massachusetts and Connecticut, in

which the increments, during the three periods embraced by the Table, present any thing like an uniformity in their rates of increase. It is curious to compare the increments of New York with those of Virginia. In 1790, the latter state possessed a greater population than any other American state; but the large increments received by the population of New York, accelerated its population in a more rapid degree than that of Virginia; so that in 1820, the province of New York possessed the maximum population. Hence, in the short space of thirty years, the population of New York was increased from 340,120 to 1,372,812; being more than quadrupled in that time. Virginia, during the same interval, only changed its population from 747,160 to 1,065,366; so that while the former state increased its inhabitants in the ratio of 8 to 2, the latter only augmented it in the ratio of 3 to 2: a difference, I should apprehend, not to be accounted for from the ordinary laws of human procreation. Pennsylvania increased its population in the same time, in about the ratio of 5 to 2. Louisiana, presents the most remarkable increase in the whole series. The increment in ten years was 635.9 per cent; so that here is an example of a population being more than sextupled in the short space of ten years. The larger class of increments, it will be perceived, form no inconsiderable portion of the Table. In the whole Table there will be found eleven increments below 10 per cent; seventeen increments between 10 and 20 per cent; five between 20 and 30 per cent; nine between 30 and 40; one between 40 and 50; three between 50 and 60; three also between 60 and 70; one between 70 and 80; four between 80 and 90; one between 90 and 100; two between 100 and 200; three between 300 and 400; and three between 400 and 700. Rhode Island, in the period from 1790 to 1800, and Delaware in that from 1810 to 1820, are the only instances of a close approximation of the population to a stationary state.

Having made these few brief observations on the increments which the different states have received, since the first authentic census of the American people in 1790; it may be useful, in the next place, to examine the increments which the free white males and females, of the different ages, have received in the aggregate of all the states and territories, during the same periods. For this purpose, the following Table has been computed:

| | AGES. | MALES. Increase per cent. | FEMALES. Increase per cent. |
|---|---|---|---|
| First period, from 1790 to 1800. | Under sixteen, - - - | 31.8 | |
| | Sixteen and upwards, - - | 33.8 | |
| | All ages, - - - - | | 35.6 |
| Second period, from 1800 to 1810. | Under ten years, - - - | 45.0 | 35.2 |
| | Ten, and under sixteen, - | 36.4 | 38.6 |
| | Sixteen, and under twenty-six, | 39.3 | 39.8 |
| | Twenty-six, and under forty-five, | 32.3 | 34.2 |
| | Forty-five and upwards, - - | 38.8 | 32.8 |
| Third period, from 1810 to 1820. | Under ten years, - - - | 29.9 | 30.4 |
| | Ten, and under sixteen, - | 30.7 | 34.9 |
| | Sixteen, and under twenty-six, | 37.8 | 39.0 |
| | Twenty-six, and under forty-five, | 33.7 | 35.3 |
| | Forty-five and upwards, - | 35.6 | 36.3 |

In the division of this Table, which comprises the period from 1800 to 1810, the male increment attains it maximum, in the class of persons under ten years of age; and its least value in the class of twenty-six, and under forty-five. In the same division, the maximum of female increment occurs in the class of persons of sixteen, and under twenty-six, and accords with the greatest male and female increments of the succeeding division. In this last division also, the minimum increments occur for each sex, in the class of persons under ten years of age. The male and female increments of the class of persons under ten years of age, in the second division, exhibit a remarkable contrast to the corresponding increments of the third division; the former having a difference of nearly 10 per cent in the rates of their increase, while the latter is nearly in a state of equality. The same remark will also apply to the class of forty-five and upwards, in the same divisions: for in the second division, the male increment of this class has an ascendency over the female increment of the same class of 6 per cent; whereas the corresponding increments of the succeeding division approach nearly to a state of equality. The near approximation also of the four rates of increase belonging to the class of persons of sixteen and under twenty-six, in the second and third divisions, is not unworthy of attention. All the male increments, excepting the first, in the second division of the Table, are less than their corresponding female increments; and in the third division, the female increments in every case exceed their corresponding

male increments. These rates of increase exhibit a greater uniformity than we should at first be led to expect.

The increments of the ages contained in the preceding Table, were deduced from the aggregate population of all the states and territories, during the several periods indicated in it. In the next place, therefore, we shall proceed to the consideration of the various increments which each age and sex has received, in every individual state; and for this purpose the following Table has been computed, to illustrate the period comprised between 1790 and 1800.

| | States & Territories. | Free white Males under 16 years. | Free white Males of 16 years and upwards. | Free white Females of all ages. |
|---|---|---|---|---|
| North. States. | Maine, | 62.7 | 49.9 | 58.0 |
| | New Hampshire, | 30.8 | 26.3 | 30.8 |
| | Massachusetts, | 10.2 | 14.2 | 10.8 |
| | Rhode Island, | 3.2 | 3.4 | 2.8 |
| | Connecticut, | 5.4 | 5.5 | 5.2 |
| | Vermont, | 85.7 | 68.7 | 84.1 |
| Mid. States. | New York, | 84.8 | 70.5 | 76.0 |
| | New Jersey, | 20.1 | 8.0 | 14.8 |
| | Pennsylvania, | 39.6 | 37.3 | 37.9 |
| | Delaware, | 4.5 | 4.8 | 10.9 |
| | Ohio, | 26.6 | 82.2 | 34.0 |
| South. States. | Maryland, | 7.7 | 7.5 | 6.8 |
| | Virginia, | 14.4 | 16.5 | 17.3 |
| | North Carolina, | 16.4 | 16.4 | 18.1 |
| | South Carolina, | 40.2 | 33.1 | 42.6 |
| | Georgia, | 101.6 | 95.8 | 87.6 |
| | Kentucky, | 200.9 | 181.4 | 197.1 |

The irregularity in these increments is very remarkable. In three of the northern states, viz. Maine, New Hampshire, and Vermont; three also of the middle states, viz. New York, New Jersey, and Pennsylvania; and likewise in four of the southern states, namely, Maryland, South Carolina, Georgia, and Kentucky,—the free male increments under 16 years of age exceed the corresponding increments of the class above sixteen. In North Carolina the two increments are precisely the same; and in Connecticut they may be nearly regarded as such. Rhode Island presents the only instance of a decrement. The most remarkable disparity in the increments of the two classes is in the state of Ohio, where the difference amounts to 55.6 per cent; a circumstance most probably to

be accounted for, from a considerable increase of the second class, by immigration. The greatest difference in any of the other states amounts only to 17 per cent. In the northern states, Vermont received the greatest increment, and Rhode Island the least. In the middle states, New York had the largest increase, and Delaware the smallest; and in the southern states, Kentucky experienced the greatest increment, and Maryland the smallest. Kentucky indeed received a larger increment than any other state, and Rhode Island a smaller, not only in both classes of males, but also in the class of females. Connecticut and Maryland present the greatest degree of uniformity in their increments, and Ohio the least. It is most remarkable, however, that notwithstanding the male and female increments appear so very irregular, it seems impossible to trace the existence of any law, or uniformity of principle, yet that the sum of the female increments should agree within $\frac{1}{10}$th of the mean of the sum of the two classes of males: the sum of the female increments amounts to 734.8, and the mean of the sums of the males to 734.9,—a coincidence most striking and singular*.

The next Table relates to the various rates of increase in the different ages, and in the different states and territories,

* Mr Stewart, in the second volume of his Philosophy of the Human Mind, page 231, when speaking of the uniformity of the course of nature, has the following remarks. "How accidental soever these circumstances may appear, and how much soever they may be placed, when individually considered, beyond the reach of our calculations, experience shews, that they are somehow or other mutually adjusted, so as to produce a certain degree of uniformity in the result; and this uniformity is the more complete, the greater is the number of circumstances combined. What can appear more uncertain than the proportion between the sexes among the children of the same family! and yet how wonderfully is the balance preserved in the case of a numerous society! What more precarious than the duration of life in an individual! and yet, in a long list of persons of the same age, and placed in the same circumstances, the mean duration of life is found to vary within very narrow limits. In an extensive district, too, a considerable degree of regularity may sometimes be traced for a course of years, in the proportion of births and deaths to the number of the whole inhabitants. Thus, in France, Necker informs us, that the number of births is in proportion to that of the inhabitants as one to twenty-three and twenty-four, in the districts that are not favoured by nature, nor by moral circumstances: this proportion is as one to twenty-five, twenty-five and a half, and twenty-six, in the greatest part of France; in cities, as one to twenty-seven, twenty-eight, twenty-nine, and even thirty, according to their extent and trade. Such proportions, Necker observes, can only be remarked in districts where there are no settlers nor emigrants; *but even the differences arising from these, and many other causes, acquire a kind of uniformity, when collectively considered, and in the immense extent of so great a kingdom.*"

in the period comprised between the enumerations of 1800 and 1810.

| States and Territories. | Males. | | | | | Females. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Under 10. | 10 and under 16. | 16 and under 26. | 26 and under 45. | 45 and upwards. | Under 10. | 10 and under 16. | 16 and under 26. | 26 and under 45. | 45 and upwards. |
| *N. States.* | | | | | | | | | | |
| Maine, | 47.6 | 50.0 | 58.2 | 44.1 | 59.4 | 45.5 | 57.2 | 60.1 | 48.1 | 55.6 |
| N. Hamp. | 11.7 | 19.9 | 15.2 | 16.6 | 23.4 | 8.2 | 21.6 | 21.2 | 19.4 | 25.2 |
| Mass. | 8.3 | 7.6 | 18.8 | 15.4 | 11.6 | 9.8 | 7.9 | 14.5 | 12.3 | 12.9 |
| R. Island, | 8.0 | 3.8 | 23.1 | 17.0 | 11.3 | 10.8 | 7.2 | 16.4 | 10.3 | 12.8 |
| Connect. | 50.4 | 5.6 | 10.1 | 2.2 | 7.9 | 0.5 | 3.9 | 6.0 | 4.4 | 9.0 |
| Vermont, | 29.4 | 52.3 | 48.6 | 25.7 | 61.6 | 29.5 | 52.6 | 74.4 | 36.6 | 62.5 |
| *M. States.* | | | | | | | | | | |
| N. York, | 65.8 | 66.5 | 74.1 | 54.0 | 69.5 | 65.4 | 74.3 | 76.9 | 52.1 | 59.1 |
| N. Jersey, | 11.5 | 19.3 | 30.2 | 7.2 | 26.7 | 10.5 | 19.9 | 24.5 | 9.4 | 30.3 |
| Penn. | 34.1 | 35.9 | 36.7 | 25.0 | 35.0 | 32.3 | 39.2 | 40.7 | 31.5 | 36.9 |
| Delaware, | 16.8 | 1.0 | 0.6 | 17.0 | 30.0 | 18.5 | 2.1 | 0.0 | 11.0 | 20.3 |
| Ohio, | 398.0 | 396.8 | 335.5 | 370.9 | 502.3 | 411.2 | 403.1 | 417.7 | 481.6 | 524.8 |
| *S. States.* | | | | | | | | | | |
| Maryland, | 3.5 | 2.9 | 2.0 | 5.7 | 8.6 | 2.4 | 4.8 | 2.5 | 3.9 | 14.3 |
| Virginia, | 5.8 | 6.0 | 5.7 | 4.6 | 16.8 | 3.9 | 8.9 | 8.2 | 23.9 | 4.5 |
| N. Car. | 7.8 | 11.9 | 9.7 | 10.4 | 13.4 | 10.7 | 16.1 | 14.9 | 10.7 | 16.6 |
| S. Car. | 6.0 | 6.4 | 17.9 | 5.9 | 10.3 | 8.2 | 4.9 | 13.4 | 10.1 | 15.8 |
| Georgia, | 41.1 | 41.1 | 43.9 | 31.7 | 49.9 | 42.8 | 42.0 | 45.6 | 39.8 | 60.2 |
| Tenn. | 131.4 | 138.7 | 135.3 | 138.9 | 158.3 | 126.6 | 131.9 | 132.2 | 152.1 | 143.1 |
| Kentucky, | 74.7 | 90.8 | 89.6 | 67.0 | 89.9 | 73.9 | 91.6 | 90.1 | 73.6 | 90.6 |
| *Territories.* | | | | | | | | | | |
| Miss. | 322.1 | 359.8 | 458.5 | 300.5 | 294.5 | 321.3 | 310.6 | 521.3 | 287.2 | 309.1 |
| Columbia. | 178.8 | 261.9 | 214.8 | 278.3 | 291.8 | 278.8 | 280.8 | 245.1 | 266.6 | 340.2 |

The district of Maine, which, in the table formed to illustrate the period from 1790 to 1800, was found to have all the increments of its different ages inferior to those of Vermont, will be found, in the preceding table, to have some of its increments superior, and some inferior, to the corresponding rates of increase in the latter state. In the male and female increments under ten, a remarkable superiority will be perceived to exist in the district of Maine; and so also in the male class of sixteen and under twenty-six, and in the male and female classes of twenty-six and under forty-five. In Vermont, a very large female increment will be found in the class of sixteen and under twenty-six; and the male and female increments under ten, will also be found approaching exceedingly near to equality. A similar approximation to equality will likewise be found to belong to the increments of both sexes, in the classes from ten to sixteen, and forty-five

and upwards. The large increment which Ohio received in the former period in the class of free males above sixteen, was succeeded by a still larger rate of increase in the period extending from 1800 to 1810; the least increment it received during that time being 335.5 per cent, and the greatest 524.8. New York, therefore, which in the preceding period stood decidedly above Ohio in the proportional magnitude of its increments, in this last period yielded to the latter state; and which also presents increments of a larger kind than any other province during the same period of time. In the southern states also, Tennessee has gained a like ascendancy over Kentucky; and of the other territories of Mississippi and Columbia, the latter is distinguished by the largest increase.

In several of the states, the increments of the different ages present instances of equality not unworthy of attention. In Vermont, New York, Kentucky, and Mississippi, the rates of increase of the males and females under ten, are very nearly the same; the difference not amounting in any case to a single unit. In New Jersey, also, the male and female increments of the class of ten, and under sixteen, present an approximation to equality. In North Carolina, the increments of the first and fourth classes of females are the same, and the second and fifth very nearly equal. In South Carolina, the male increments of the first, second, and fourth classes, are nearly the same. In Georgia, there is an absolute equality of the male increments in the first and second classes; and a near approach to the same state, in the corresponding classes of females. The increment in the last class of females, has a remarkable ascendency over the corresponding class of males. In Tennessee, the male increments of the second and fourth classes are nearly equal; as well as the female increments in the second and third classes, and the first class of males. Kentucky presents a remarkable instance of a close approach to equality, between the male and female increments, in four classes out of five, into which the ages are divided. The single class, indeed, where this degree of equality does not exist, namely, in that of twenty-six and under forty-five, the difference is not very considerable. The causes, therefore, that have operated in Kentucky to increase its population, have acted almost uniformly on all ages. In Delaware, the rates of increase are very singular. Both the male and female classes under ten, and also the fourth and fifth classes of each sex, present examples of moderate increments; but the third class of females we find stationary, the corresponding class of males with only an increment of $\frac{6}{10}$ths per cent; and in

the second class of males and females, increments almost equally feeble. The first class of males in Connecticut, and the last class of females in Virginia, present the only instances of decrements.

The maximum increments of the different ages for both sexes, appear to exist in some of the states, in the class of persons of sixteen and under twenty-six; and in other states, in the class of forty-five and upwards; the females in Virginia, Tennessee and Kentucky, being the only exceptions in this curious law. In the following columns, the states and territories are arranged, according to the ages in which the maximum increments are found.

| States and territories, in which the maximum increments of males are found. | | States and territories, in which the maximum increments of females are found. | |
|---|---|---|---|
| 16 & under 26. | 45 & upwards. | 16 & under 26. | 45 & upwards. |
| Massachusetts. | Maine. | Maine. | N. Hampshire. |
| Rhode Island. | N. Hampshire. | Massachusetts. | Connecticut. |
| Connecticut. | Vermont. | Rhode Island. | New Jersey. |
| New York. | Delaware. | Vermont. | Delaware. |
| New Jersey. | Maryland. | New York. | Maryland. |
| Pennsylvania. | Virginia. | Pennsylvania. | North Carolina. |
| South Carolina. | North Carolina. | Mississippi. | South Carolina. |
| Mississippi. | Georgia. | | Georgia. |
| | Tennessee. | | Ohio. |
| | Kentucky. | | Columbia. |
| | Ohio. | | |
| | Columbia. | | |

Although the maximum increments which both sexes have received in the period from 1800 to 1810, present a singular degree of uniformity, and appear to be the result of some law, which operates in by far the greater part of the states and territories, in such a way as to cause the maximum increments to appear either in the class of persons of sixteen and under twenty-six, or in that of forty-five and upwards, still no law appears to exist relative to the minimum increments; these being found for both sexes in every variety of age. The remark, however, relating to the maximum increments, is not unworthy of notice; and as Lord Bacon has observed in his admirable Essays, 'I would not have it given over, but waited upon a little.'

The following Table has been deduced from a comparison of the Population Returns for 1810 and 1820, and, taken in conjunction with the preceding Tables, will lead to some interesting results.

| States and Territories. | Males. | | | | | Females. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Under 10. | 10 and under 16. | 16 and under 26. | 26 and under 45. | 45 and upwards. | Under 10. | 10 and under 16. | 16 and under 26. | 26 and under 45. | 45 and upwards. |
| *N. States.* | | | | | | | | | | |
| Maine, | 19.2 | 14.7 | 39.8 | 25.6 | 44.3 | 18.9 | 34.5 | 44.8 | 31.6 | 48.0 |
| N. Hamp. | 3.4 | 10.3 | 20.4 | 11.8 | 27.3 | 7.1 | 9.5 | 19.3 | 17.6 | 31.1 |
| Mass. | 2.9 | 10.3 | 9.9 | 18.7 | 10.6 | 3.6 | 15.7 | 13.9 | 17.2 | 15.7 |
| R. Island, | 7.4 | 5.5 | 4.8 | 12.6 | 8.3 | 3.4 | 7.1 | 11.8 | 13.6 | 12.3 |
| Conn. | 2.6 | 0.9 | 8.2 | 8.2 | 6.5 | 1.8 | 4.8 | 8.9 | 10.6 | 10.1 |
| Vermont, | 6.6 | 4.9 | 22.7 | 6.0 | 24.0 | 3.7 | 7.1 | 17.8 | 13.9 | 32.9 |
| *M. States.* | | | | | | | | | | |
| N. York, | 34.2 | 41.4 | 54.8 | 46.1 | 50.5 | 37.1 | 48.1 | 55.6 | 51.4 | 54.9 |
| N. Jersey, | 11.2 | 5.6 | 16.1 | 14.1 | 15.8 | 10.7 | 9.7 | 20.9 | 15.6 | 19.4 |
| Penn. | 26.6 | 23.1 | 38.2 | 30.9 | 23.8 | 26.5 | 28.7 | 33.5 | 33.2 | 30.3 |
| Delaware, | 6.2 | 0.1 | 7.1 | 4.6 | 13.4 | 4.4 | 1.4 | 0.6 | 0.2 | 14.7 |
| Ohio, | 139.5 | 153.1 | 182.4 | 139.5 | 164.3 | 139.9 | 161.5 | 166.8 | 151.1 | 171.8 |
| Indiana, | 501.8 | 495.9 | 531.7 | 507.6 | 528.1 | 507.7 | 474.7 | 511.9 | 538.8 | 539.0 |
| *S. States.* | | | | | | | | | | |
| Maryland, | 7.5 | 2.5 | 16.4 | 10.5 | 11.8 | 9.2 | 9.8 | 14.3 | 15.0 | 11.7 |
| Virginia, | 6.3 | 6.6 | 14.4 | 10.1 | 8.3 | 8.6 | 8.4 | 13.7 | 9.4 | 9.8 |
| N. Car. | 10.9 | 8.5 | 14.1 | 5.2 | 20.1 | 8.5 | 10.1 | 11.4 | 12.2 | 23.0 |
| S. Car. | 5.1 | 3.7 | 11.6 | 5.3 | 20.2 | 3.9 | 10.1 | 12.5 | 7.6 | 18.4 |
| Georgia, | 26.6 | 23.4 | 38.3 | 24.4 | 46.1 | 26.2 | 32.9 | 38.5 | 23.9 | 44.9 |
| Louisiana, | 243.7 | 250.2 | 457.8 | 443.1 | 398.7 | 244.3 | 333.5 | 368.8 | 315.9 | 451.9 |
| Tenn. | 52.3 | 65.9 | 59.2 | 37.0 | 76.2 | 51.7 | 70.1 | 58.9 | 56.8 | 84.3 |
| Kentucky, | 27.5 | 34.3 | 38.8 | 29.2 | 43.3 | 27.7 | 36.4 | 42.0 | 36.9 | 54.3 |
| *Territories.* | | | | | | | | | | |
| Alabama, | 192.5 | 152.1 | 215.1 | 76.4 | 62.0 | 193.6 | 143.0 | 178.1 | 118.9 | 93.1 |
| Miss. | 92.2 | 96.5 | 69.4 | 61.7 | 100.7 | 79.8 | 105.7 | 73.3 | 77.2 | 136.4 |
| Illinois, | 365.8 | 37.3 | 388.6 | 329.8 | 375.0 | 373.4 | 408.0 | 359.8 | 366.0 | 395.3 |
| Michigan, | 52.5 | 65.0 | 128.8 | 117.7 | 79.1 | 76.5 | 58.1 | 88.0 | 91.3 | 104.6 |
| Columbia, | 32.2 | 32.1 | 42.8 | 37.3 | 49.1 | 30.8 | 37.6 | 52.3 | 50.8 | 62.4 |

(To be continued.)

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Art. II.—*Analysis of a Paper on the Finite Extent of the Atmosphere.* By W. H. Wollaston, M. D. V. P. R. S*. [*Edin. Phil. Jour.*]

If air consist of ultimate particles, whose divisibility has a limit, an atmosphere composed of such particles must have a finite extent, because it cannot expand beyond that distance at which the force of gravity upon a single particle is equal to the resistance arising from the repulsive force of the me-

* Read before the Royal Society on the 17th January, 1822.

dium. In order to ascertain whether or not this is the constitution of our atmosphere, Dr Wollaston considers what would be the effect of an unlimited expansion of an atmosphere, and finding that no such effects are exhibited in any of the bodies of the planetary system, he concludes that these bodies have not an atmosphere of indefinite extent; that the earth's atmosphere is also limited, and consequently, that matter has a finite divisibility, and that the doctrine of ultimate atoms is thus indirectly established.

If the expansion of any atmosphere is unlimited, the same kind of matter must pervade all space, and the sun, moon, and all the planets must have this matter condensed around them in quantities dependent on the force of their respective attractions. For the purpose of determining if such an accumulation of matter does exist round any of the planetary bodies, he begins with the Sun, which, on account of its having the greatest mass, ought to accumulate round it the greatest quantity of atmospherical matter.

Assuming the sun's mass as 330,000 times that of the earth, and his radius 111.5 times that of the earth, he finds that the distance from the sun's centre at which his atmosphere will have a density fully equal to our own, and therefore capable of refracting a ray of light more than one degree, is $=\sqrt{330{,}000}=575$ times the earth's radius, $=\frac{575}{111.5}=5.15$ times the sun's radius; that is, a point whose angular distance from the sun's centre is $15' \, 49'' \times 5.15 = 1° \, 21' \, 29''$.

Now, if any of the planets or stars, in approaching the sun's disc, suffer no refraction at all, when carefully observed at the above distance, or at less distances from the sun's centre, we may safely conclude that no such atmosphere exists.

In order to determine this point, Captain Kater made a series of observations on Venus on the 18th and 19th of May 1821, when she was on the eve of her conjunction with the sun, and Dr Wollaston made similar ones after her conjunction. Captain Kater's last observation was made when Venus was only 65′ 50″ from the sun's centre; and Dr Wollaston's when her distance was only 53′ 15″; and at both these times, neither her motion nor her position were in the least affected by a solar atmosphere. In 1805, M. Vidal of Montpellier observed Venus when her distance from his centre was only 46′, and Mercury when his distance was only 65′; and in both these cases, the observed and the calculated positions agree exactly.

These arguments receive, if they required it, additional strength from the phenomena of the eclipses of Jupiter's satellites. These bodies advance regularly, and without any retardation from refraction, to the very disc of the planet; so that Jupiter cannot possess that extent of atmosphere which he is capable of attracting to himself from an infinitely divisible medium filling space. For, taking Jupiter's mass at 309 times that of the Earth, and his diameter at 11 times that of the Earth, then $\sqrt{309}=17.6$ times the Earth's radius, $=\frac{17.6}{11}=1.6$ times his own radius, which will be the distance from his centre at which an atmosphere equal to our own should produce a refraction of one degree. To the fourth satellite this distance would subtend an angle of about 3° 37′; so that an increase of density to $3\frac{1}{4}$ times our common atmosphere, would be more than sufficient to render the fourth satellite visible to us *when behind the centre of the planet, and consequently, to appear on both* (or all) *sides at the same time.* The space of about 6 inches in depth within which this increase of density would take place, would not subtend so much as $\frac{1}{300}$th of a second.

Hence, Dr Wollaston concludes, *that all the phenomena accord entirely with the supposition that the Earth's atmosphere is of finite extent, limited by the weight of ultimate atoms, of definite magnitude, no longer divisible by repulsion of their parts.*

Having thus stated Dr Wollaston's reasoning as perspicuously as we can, we shall lay before the reader, in his own words, a description of the apparatus which he employed.

"If I were to describe the little telescope with which my observations were made, without taking due care to explain the precautions adopted, and the grounds of their efficacy, it might perhaps be scarcely credible, that, with an object-glass less than one inch in aperture, having a focal length of only seven inches, I could discern an object not to be seen by telescopes of four and five inches aperture. We know, however, that this small aperture is abundantly sufficient for viewing Venus at a distance from the Sun; and since the principal obstruction to seeing her nearer, when the atmosphere is clear, arises from the glare of false light upon the object-glass, the success of the observation depends entirely on having an effectual screen for the whole object-glass, which is obviously far more easy to accomplish in the smaller telescope.

"Since the screen which I employed was about six feet distant from my object-glass, a similar protection for an aper-

ture of five inches would have required to be at the distance of thirty feet, to obviate equally the interference of the sun's light at the same period; but this is a provision with which regular observatories are not furnished for the common purposes of astronomy.

"As I hope at some future time to avail myself of a larger aperture for such observations, without the necessity of mounting a more distant screen, it may be desirable that I should suggest to others the means by which this may be effected, if they think the question of a solar atmosphere worthy of farther investigation. If an object-glass of four inches aperture be covered so as to expose only a vertical slit of its surface one inch in width, the surface of glass to be so used is about five times as large as the circular aperture, one inch in diameter, and yet will be as completely shaded by a vertical screen at any given distance; and an interval of only five feet might allow a star or planet to be seen within a degree of the sun's disc.

"When the sun and planet have the same declination, the vertical position of the slit is manifestly the most advantageous that could be chosen on the meridian; but, for the purpose of seeing to the greatest advantage when the line of the centres is inclined to the horizon, it would be requisite to have the power of turning the slit and screen together, at right angles to any line of direction of the centres.

"The only fixed star sufficiently near to the ecliptic, and bright enough to give any prospect of its being seen near the sun, is Regulus, which passes between the 20th and 21st of August; but I have not yet had an opportunity of ascertaining within what distance from the sun this star can be discerned."

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ART. III.—*On the Advantages of the Curvilinear Form introduced by* Sir ROBERT SEPPINGS, *in the Construction of the Sterns of British Ships of War.* By JOHN KNOWLES, Esq. F. R. S. [*Jour. of the Roy. Ins.*]

To examine with caution, and, indeed, with prejudice, every deviation from that which has been established by custom, seems to be a natural operation of the human mind; hence, it has been the fate of almost all the important improvements

which have been introduced in science or in art, to meet with opposition from the prejudiced in favour of former practices, as well as from those who consider that their private interests are likely to be sacrificed by the change.

With such feelings some persons have viewed a recent improvement in the practice of naval architecture, that of giving to the sterns of our ships of war a curvilinear form, and have, consequently, indulged in asperity of criticism, which has, however, only tended to shew their ignorance of the system.

To prove the advantages which arise from this innovation, Sir Robert Seppings has recently printed, and privately circulated a letter addressed to Viscount Melville, which, if published, would leave but little to add to the inquiry; but as this is not the case, it is considered that a description of these (which have usually been called circular) sterns, and a statement of the advantages arising from them, founded chiefly upon the facts adduced by Sir Robert, will not be unacceptable to the public.

But before we enter upon this description, it will be necessary to give, in order to elucidate the subject, an historical sketch of the manner in which the sterns of ships have hitherto been constructed, and we shall commence our inquiry at the reign of Henry VIII. a period when the fancies of speculation gave way to the delineation of the artist.

In the 16th century the sterns of the ships of the largest class were formed square, not only above, but for some feet below, the line of water, and were adorned with carved work and banners. The shape of these sterns admitted of four guns of large calibre, being fired right aft. We learn from the picture preserved in the Society of Antiquaries, of the embarkation of Henry VIII. at Dover, in the year 1520, (which, no doubt, was painted at the time, but has been incorrectly ascribed to the pencil of Holbein,) that ships at that period had neither stern-walks, balconies, nor quarter galleries, nor is there represented the convenience of a water-closet abaft, even in the ship occupied by His Majesty; and but one only in the squadron, which is in a ship bearing the royal standard, and which it is evident, from the colouring, was an appendage for the occasion, and probably put up for the accommodation of the Queen of England, and her court. The sterns of these ships were, no doubt, formed by several beams of considerable dimensions, called transoms, lying horizontally, and attached to their frames or ribs, by large

crooked pieces of timber called knees; these, it would seem, prevented the working of the guns in the quarters to any effect.

In the beginning of the 17th century our ships of war were much improved, not only by an increase of their dimensions, but also by the application of science to the construction of their bodies; fortunately this opinion does not rest upon mere speculation, Sir Robert Seppings having in his possession a complete draught of the Sovereign, launched in the year 1637. This ship was designed by Mr Phineas Pett, to whose memory the civil departments of the navy owe much for his scientific knowledge and judicious arrangements: this, then, may be regarded as the era when the body of a ship was constructed upon scientific principles. It appears that Mr Pett had, previously to his becoming a naval architect, taken the degree of Master of Arts, at the University of Cambridge; and the excellency of this drawing, and the wide range of improvement in a short period, shew the great advantages that are derived by a combination of mathematical learning, with practical architecture. The stern of the Sovereign is improved by being rounded below and a little above the seat of water; she had five transoms, and stern and quarter galleries, or balconies; her draught of water abaft was twenty-two feet three inches, the height of the stern above the water fifty feet nine inches, and she originally had six decks or platforms abaft, on which guns might be carried. Contemporary writers say, that "she was built for shew and magnificence, but that being taken down a deck lower, she became one of the best men-of-war in the world." The only deck which could have been removed was the top-gallant round-house, or poop-royal, as it is sometimes called, which, by lowering the stern about six feet, no doubt, would render her a better ship for sea purposes. This opinion is founded upon official documents, for it appears the Sovereign was always considered a first-rate until taken to pieces to be rebuilt. It is worthy to be placed upon record, that it was not only the sterns of ships, at the period of which we are speaking, that were overloaded with ornaments, but the heads also, for the prow of this ship extended forty-three feet six inches from the line of fluitation, and was covered with massive carved work.

The cumbrous and expensive mode of building and ornamenting the heads and sterns of ships of the first class, continued until the year 1699, when directions were given by the government "to be more sparing in the carved work, and

other decorations." The balconies in the quarters were, however, fitted until the year 1729, when these projections were discontinued, and close galleries adopted.

To lower the height, and to lessen the weight, of the sterns in large ships, the poops royal were omitted in those built and repaired after the middle of the last century. From this period little appears to have been done to alter or amend the heads and sterns of our ships of war, as they still continued to exhibit massive carved work, which was a disgrace to the taste and science of the country, until the year 1796, when Earl Spencer, who carries his scientific knowledge into all the useful concerns of life, being then First Lord of the Admiralty, directed that the ponderous heads should no longer be continued, nor should there be galleries or carved work in their sterns. Although this was a considerable step towards improvement, by reducing the weights in the extremities of ships, nothing was done to render them stronger in those parts by a different disposition or combination of materials, until the year 1811, when Sir Robert Seppings introduced a method of strengthening the bow, and affording protection to the mariners, by carrying up the timbers so as to form a round bow; and subsequently in June, 1816, he proposed that the same system should be adopted in the stern, a part that still more required to be strengthened, so as to form the circular stern which is the subject of the present essay.

The advantages derived from the circular sterns may be classed under the following heads:

1st. A considerable addition to the strength of the ships.

2nd. Safety to the people employed in them, both from the effects of a sea striking their sterns, and from shot fired by the enemy.

3rd. The additional means afforded for attack or defence.

4th. The improvement in the sailing qualities of the ships by the removal of the quarter galleries.

The insufficiency in point of strength of the old method of constructing the sterns, is proved in Sir Robert Seppings's letter, by his giving, from official reports, eighty-nine instances in ships of the line, and eighty in frigates, of the great weakness of that part of the ships; many of these were commanded by officers who were celebrated for activity and prowess during the two last wars. This defect being so general, led to the consideration of the best mode of remedying it; and the acknowledged strength of the round bow, a part subjected to the action of far greater forces and strains than

the stern, naturally led to the consideration of fortifying the latter by the same mode of timbering, and from this arose the circular stern. Before the introduction of this system, the new mode of ship building might truly be said to be incomplete, for the shelf-pieces and waterways, as well as all the planking above the wing transom, which may be called internal and external hoops, were cut off, and hence left the stern the only weak part in the ship; for it is an axiom in mechanics that the strength of any fabric may be measured by the weakest part, subjected to the like strains or action. It is, then, the mode of timbering these sterns, and a continuity of the internal and external planking that constitute their strength, and establish the principle; the different methods that may be devised of placing the decorations or accommodations, have little to do with the system, as long as these methods are preserved.

The safety which the present method of constructing the sterns affords to the seamen, over that of the old plan, is best shewn by some instances of the danger arising from the imperfections of the latter method, which, above the wing transom presented little else than glazed windows. The Dictator, of 64 guns, in her passage from the West Indies in the year 1797, was struck by the sea on the stern, which stove in the dead lights and window frames, washed away every thing on the main deck, and the crew were under the necessity of throwing six of the guns overboard to lighten the ship abaft. The Revolutionaire, of 46 guns, on her passage also from the West Indies, in the year 1804, met with a similar accident, which also stove in the dead lights, and carried away the bulkhead of the great cabin; and had not the hatchways been barred down, which prevented the water from getting into the hold, the ship must have foundered.

In the sterns formed according to the old plan the men on all the decks, except those on the lower gundeck in ships of the line, are exposed to the most destructive raking fire, their sterns being pervious even to a musket ball.

The strength given to the circular sterns by carrying up the timbers, prevents all the danger to be apprehended from a sea striking the ship abaft, or from the ingress of small shot, as well as from large ones which have not force to pass through the timbers and planking. And from their curved form, the shocks of the sea abaft will be much lessened, and those shot fired at an angle of, and at more than 45°, will glance off without doing much injury to the ships.

When we consider that according to the present method of constructing the sterns, the guns can be run out in that part, pointed, elevated, or depressed, with as much facility, and in the same manner, that those are in the sides of the ships; and that the fire can be varied in all directions from the semicircular form of the stern, the subject of the means afforded for attack or defence in this quarter need not be further insisted upon; but a most important port for a gun has been added to each deck in the situation that the quarter galleries formerly occupied. The necessity of having guns in this place will be shewn hereafter by some examples of the want of them in the ships built according to the old form; indeed, when an enemy's ship has lain upon the quarters of any vessel, it has technically been called the point of impunity, from the circumstance of their bringing many guns to bear, and their opponent not being able to fire one shot with effect. Sir Robert Seppings has stated, in his letter before alluded to, that, according to the present disposition of the ports, "a three-decked ship, if attacked abaft, can bring at least ten guns to bear upon her assailant, a two-decked ship eight, and a frigate four."

In the old sterns the guns on the lower gun-decks could not be fired without injury to the ships, from the effects of concussion on their projecting counters; and on the other decks the breadth of the transoms prevented their being run out sufficiently, and the height of those beams above the decks hindered the guns from being depressed.

To prove these facts many instances have been adduced, and among them that of the masterly retreat of Admiral Cornwallis before a French fleet of very superior force; to accomplish this, by annoying the enemy, the ships were obliged to be so mutilated in their sterns, in order to be enabled to fire guns right aft, that on their arrival in port they had to undergo very considerable repairs before they were again considered sea worthy.

Among the many instances on record of the danger arising from the want of guns in the quarters of ships, may be cited the fact, that Admiral Sir Sidney Smith took his station in Swedish gun-boats, (propelled with oars,) on the quarters of the ships of a Russian fleet, and so annoyed them, that they may be said to have suffered a defeat, arising from the circumstance of their not being able to bring any guns to bear upon those boats.

The weight of the additional timbers placed in the circular sterns is more than compensated by the omission of transoms, sleepers, and useless decorations, as well as by a less projection of the sterns above water; and as the ships now have the same form below, and for some feet above the line of fluitation, they, consequently, have the same buoyancy abaft as those built according to the old plan. Their sea-going properties are, however, improved by the omission of quarter galleries, which acted as a back sail when the ships were going on a wind.

But it may be said, these advantages appear to be feasible from analogy, but what direct proofs are there from experience that such are derived from the circular sterns? The answer to this is, the Owen Glendower, of 42 guns, was employed for rather more than two years on the South American station; the Aurora frigate is now on that station; and the Ganges, of 84 guns, has lately come from the East Indies; all these ships have circular sterns, of which their commanders have spoken in the most favourable terms. The Ganges, on her passage home, encountered, off the Cape of Good Hope, a gale of wind, twenty-nine days in continuance, and "although the ship was repeatedly wore that she might be longer before the sea, which was tremendous," to try the effect of the shape given to the sterns, "she never threw the water into the ward-room, and not a spray ever wetted the stern-walk."

As the circular sterns have been examined as to all the essential requisites in a ship of war, it remains to be seen how far they may be wanting in external appearance, or internal accommodation. It is difficult to separate the preconceived notion of what a ship was, from what she ought to be; and still more difficult to lay down a rule of what may be deemed beauty in naval architecture, for this at last must be arbitrary. M. Charles Dupin, speaking upon this point, considers beauty to consist in that which is the most fitting for its object, for he says, that stern only "can be beautiful, when the appearance of its force shall command respect from the feelings of the enemy*." If this opinion be granted, the circular sterns are, in a high degree, beautiful.

* "Attaquons surtout ces fausses idées qui font entrer en balance avec la force réelle des bâtimens de guerre, de futiles et vains caprices de goût, d'ornement, de décoration, pour un édifice qui sera d'une beauté parfaite, aussitôt que l'aspect de sa force commandera le respect dans l'âme de l'ennemi." *Force navale de la Grande—Bretagne, par* Charles Dupin.

The only apparent difference in size in the captain's cabin and ward-room is the difference between the overhanging of the old and new sterns; and this is not real, if the area be considered, for the transoms, and their securities, occupied a considerable space. It must be allowed that at present there are less stern windows, but there is still a sufficiency of light and air from those now placed in the stern, as well as from the ports and sky-lights. By the removal of timbers called sleepers, the internal accommodations for the reception of bread is augmented; for the bread-room in a 74 gun ship has 313 cubic feet more of space than in one with the old stern.

The present method of building ships' sterns has gone too far to be shaken by prejudice, or discontinued in consequence of the cavils of those who consider that every thing is to be sacrificed to appearance, or what they vainly imagine personal comforts; and we find that the other naval powers with whom, at no very distant period, we may have to contend, have justly appreciated the plan. The Dutch have altogether adopted this, as well as the other inventions of Sir Robert Seppings. The Americans are now building ships with circular sterns*. And the French have either been persuaded into the system by the force of eloquence used by their most elegant and acute writer on naval affairs (Charles Dupin), or driven into it by the strain of irony with which he has treated the tardiness of the government in adopting what he considers a most important improvement. In consequence of this, French ships have been built with circular sterns, and they have a frigate of the largest class with such a stern, now employed in South America.

Dear bought experience having taught us how dangerous it is to hold an enemy too cheap, or to combat upon unequal terms, establishes the practice, and stamps the necessity of constructing our ships according to that method which shall unite safety with the greatest force that can be brought to bear, in any point, upon the ships of the enemy.

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* The circular stern has not yet been adopted in the United States navy to the extent that the above expression would lead one to conclude. A single vessel is we understand now building on this plan, under the direction of Captain MORRIS.—*Ed. B. J.*

Art. IV.—*On Sounds inaudible by certain Ears.* By William Hyde Wollaston, M. D. F. R. S. [*Philosophical Transactions.*]

It is not my intention to occupy the time of this Society, with the consideration of that mere general dulness to the impression of all kinds of sound which constitutes ordinary deafness, but to request its attention to certain peculiarities that I have observed with respect to partial insensibility in different states of the ear, and in different individuals; for I have found that an ear, which would be considered as perfect with regard to the generality of sounds, may, at the same time, be completely insensible to such as are at one or the other extremity of the scale of musical notes, the hearing or not hearing of which seems to depend wholly on the pitch or frequency of vibration constituting the note, and not upon the intensity or loudness of the noise.

Indeed, although persons labouring under common deafness have an imperfect perception of all sounds, the degree of indistinctness of different sounds is commonly not the same; for it will be found upon examination, that they usually hear sharp sounds much better than low ones; they distinguish the voices of women and children better than the deeper tones in which men commonly speak; and it may be remarked, that the generality of persons accustomed to speak to those who are deaf, seem practically aware of this difference, and, even without reflecting upon the motives which guide them, acquire a habit of speaking to deaf persons in a shriller tone of voice, as a method by which they succeed in making them hear more effectually than by merely speaking louder.

In elucidation of this state of hearing, which casually occurs as a malady, I have observed, that other ears may for a time be reduced to the same condition of insensibility to low sounds. I was originally led to this observation, in endeavouring to investigate the cause of deafness in a friend, by trial of different modes of closing, or otherwise lessening the sensibility of my own ears. I remarked, that when the mouth and nose are shut, the tympanum may be so exhausted by a forcible attempt to take breath by expansion of the chest, that the pressure of the external air is strongly felt upon the membrana tympani, and that, in this state of tension from external pressure, the ear becomes insensible to grave tones,

without loosing in any degree the perception of sharper sounds.

The state to which the ear is thus reduced by exhaustion, may even be preserved for a certain time, without the continued effort of inspiration, and without even stopping the breath, since, by sudden cessation of the effort, the internal passage to the ear becomes closed by the flexibility of the Eustachian tube, which acts as a valve, and prevents the return of air into the tympanum. As the defect thus occasioned is voluntary, so also is the remedy; for the unpleasant sensation of pressure on the drum, and the partial deafness which accompanies it, may at any instant be removed by the act of swallowing, which opens the tube, and by allowing the air to enter, restores the equilibrium of pressure necessary to the due performance of the functions of the ear.

In my endeavours to ascertain the extent to which this kind of deafness may be carried, some doubt has arisen, from the difficulty of finding sounds sufficiently pure for the purpose. The sounds of stringed instruments are in this respect defective; for unless the notes produced are free from any intermixture of their sharper chords, some degree of deception is very liable to occur in the estimate of the lowest note really heard. I can, nevertheless, with considerable confidence, say, that my own ears may be rendered insensible to all sounds below F marked by the base clef. But as I have been in the habit of making the experiment frequently, it is probable that other persons who may be inclined to repeat it, will not with equal facility effect so high a degree of exhaustion as I have done. To a moderate extent the experiment is not difficult, and well worth making. The effect is singularly striking, and may aptly be compared to the mechanical separation of larger and smaller bodies by a sieve. If I strike the table before me with the end of my finger, the whole board sounds with a deep dull note. If I strike it with my nail, there is also at the same time a sharp sound produced by quicker vibrations of parts around the point of contact. When the ear is exhausted it hears only the latter sound, without perceiving in any degree the deeper note of the whole table. In the same manner, in listening to the sound of a carriage, the deeper rumbling noise of the body is no longer heard by an exhausted ear; but the rattle of a chain or loose screw remains at least as audible as before exhaustion.

Although I cannot propose such an experiment as a means of improving the effect of good music, yet, as a source of

amusement even from a defective performance, I have occasionally tried it at a concert with singular effect; since none of the sharper sounds are lost, but by the suppression of a great mass of louder sounds, the shriller ones are so much the more distinctly perceived, even to the rattling of the keys of a bad instrument, or scraping of catgut unskillfully touched.

Those who attempt exhaustion of the ear for the first time, rarely have any difficulty in making themselves sensible of external pressure on the tympanum; but it is not easy at first to relax the effort of inspiration with sufficient suddenness to close the Eustachian tube, and thus maintain the exhaustion; neither is it very easy to refrain long together from swallowing the saliva, which instantly puts an end to the experiment.

I may here remark, that this state of excessive tension of the tympanum is sometimes produced by sudden increase of external pressure, as well as by decrease of that within, as is often felt in the diving-bell as soon as it touches the water; the pressure of which upon the included air closes the Eustachian tube, and, in proportion to the descent, occasions a degree of tension on the tympanum, that becomes distressing to persons who have not learned to obviate this inconvenience. Those who are accustomed to descend, probably acquire the art of opening the Eustachian tube by swallowing, or incipient yawning, as soon as the diving-bell touches the water.

It seems highly probable, that in the state of artificial tension thus produced, a corresponding deafness to low tones is occasioned; but, as I never have been in that situation, I have not had an opportunity of ascertaining this point by direct experiment.

In the natural healthy state of the human ear, there does not seem to be any strict limit to our power of discerning low sounds. In listening to those pulsatory vibrations of the air of which sounds consist, if they become less and less frequent, we may doubt at what point tones suited to produce any musical effect terminate; yet all persons but those whose organs are palpably defective, continue sensible of vibratory motion, until it becomes a mere tremor, which may be felt and even almost counted.

On the contrary, if we turn our attention to the opposite extremity of the scale of audible sounds, and, with a series of pipes exceeding each other in sharpness, if we examine the effects of them succesively upon the ears of any considerable number of persons, we shall find (even within the range

of those tones which are produced for their musical effects) a very distinct and striking difference between the powers of different individuals, whose organs of hearing are in other respects perfect, and shall have reason to infer, that human hearing in general is more confined than has been supposed with regard to its perception of very acute sounds, and has probably, in every instance, some definite limit, at no great distance beyond the sounds ordinarily heard.

It is now some years since I first had occasion to notice this species of partial deafness, which I at that time supposed to be pecular to the individual in whom I observed it. While I was endeavouring to estimate the pitch of certain sharp sounds, I remarked in one of my friends a total insensibility to the sound of a small organ pipe, which, in respect to acuteness, was far within the limits of my own hearing, as well as of others of our acquaintance. By subsequent examination, we found that his sense of hearing terminated at a note four octaves above the middle E of the piano-forte. This note he seemed to hear rather imperfectly, but he could not hear the F next above it, although his hearing is in other respects as perfect, and his perception of musical pitch as correct as that of any ordinary ears.

The casual observation of this peculiarity in the organ of hearing, soon brought to my recollection a similar incapacity in a near relation of my own, whom I very well remember to have said, when I was a boy, that she never could hear the chirping that commonly occurs in hedges during a summer's evening, which I believe to be that of the gryllus campestris.

I have reason to think, that a sister of the person last alluded to had the same peculiarity of hearing, although neither of them were in any degree deaf to common sounds.

The next case which came to my knowledge was in some degree more remarkable, in as much as the deafness in all probability extended a note or two lower than in the first instance. This information is derived from two ladies of my acquaintance, who agree that their father could never hear the chirping of the common house-sparrow. This is the lowest limit to acute hearing that I have met with, and I believe it to be extremely rare. Deafness even to the chirping of the house-cricket, which is several notes higher, is not common. Inability to hear the piercing squeak of the bat seems not very rare, as I have met with several instances of persons not aware of such a sound. The chirping which I sup-

pose to be that of the gryllus campestris, appears to be rather higher than that of the bat, and accordingly will approach the limit of a greater number of ears; for, as far as I am yet able to estimate, human hearing in general extends but a few notes above this pitch. I cannot, however, measure these sounds with precision; for it is difficult to make a pipe to sound such notes, and still more difficult to appreciate the degree of their acuteness.

The chirping of the sparrow will vary somewhat in its pitch, but seems to be about four octaves above E in the middle of the piano-forte.

The note of the bat may be stated at a full octave higher than the sparrow, and I believe that some insects may reach as far as one octave more; for there are sounds decidedly higher than that of a small pipe one-fourth of an inch in length, which cannot be far from six octaves above the middle E. But since this pipe is at the limit of my own hearing, I cannot judge how much the note to which I allude might exceed it in acuteness, as my knowledge of the existence of this sound is derived wholly from some young friends who were present, and heard a chirping, when I was not aware of any sound. I suppose it to have been the cry of some species of gryllus, and I imagine it to differ from the gryllus campestris, because I have often heard the cry of that insect perfectly.

From the numerous instances in which I have now witnessed the limit to acuteness of hearing, and from the distinct succession of steps that I might enumerate in the hearing of different friends, as the result of various trials that I have made among them, I am inclined to think, that at the limit of hearing, the interval of a single note between two sounds, may be sufficient to render the higher note inaudible, although the lower note is heard distinctly.

The suddenness of the transition from perfect hearing to total want of perception, occasions a degree of surprise, which renders an experiment on this subject with a series of small pipes among several persons rather amusing. It is curious to observe the change of feeling manifested by various individuals of a party in succession, as the sounds approach and pass the limits of their hearing. Those who enjoy a temporary triumph, are often compelled in their turn to acknowledge to how short a distance their little superiority extends.

Though it has not yet occurred to me to observe a limit to the hearing of sharp sound in any person under twenty years

of age, I am persuaded, by the account that I have received from others, that the youngest ears are liable to the same kind of insensibility. I have conversed with more than one person who never heard the cricket or the bat, and it appears far more likely that such sounds were always beyond their powers of perception, than that they never had been uttered in their presence.

The range of human hearing comprised between the lowest notes of the organ and the highest known cry of insects, includes more than nine octaves, the whole of which are distinctly perceptible by most ears, although the vibrations of a note at the higher extreme are six or seven hundred fold more frequent than those which constitute the gravest audible sound.

Since there is nothing in the constitution of the atmosphere to prevent the existence of vibrations incomparably more frequent than any of which we are conscious, we may imagine that animals like the grylli, whose powers appear to commence nearly where ours terminate, may have the faculty of hearing still sharper sounds, which at present we do not know to exist; and that there may be other insects hearing nothing in common with us, but endued with a power of exciting, and a sense that perceives vibrations of the same nature indeed as those which constitute our ordinary sounds, but so remote, that the animals who perceive them may be said to possess another sense, agreeing with our own solely in the medium by which it is excited, and possibly wholly unaffected by those slower vibrations of which we are sensible.

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Art. V.—*On certain Elevations of Land, connected with the Actions of Volcanoes.* By J. Mac Culloch, M. D. F. R. S. *Communicated by the author.* [*Jour. of the Roy. Ins.*]

The geological readers of this Journal need not be reminded, that one of the great problems in their science is to determine the nature of the causes whence rocks, once existing beneath the depths of the sea, are now found elevated far above its level. For proofs of the fact itself, we need not have recourse to the observations of Ulloa on the fossil shells

found at elevations of 14,000 feet in the Andes, as the whole surface of the earth presents appearances of the same nature.

Two distinct theories have been suggested for the explanation of this fact, yet without necessarily involving all the other points which have divided the two leading bodies of geological partisans. By the one party it has been attributed to the subsidence of the sea; the rocks, with their organic contents, remaining in the places where they had been formed: by the other, it has been supposed that the land has itself moved, while the sea remained at rest. In the last party also, there are some who, like De Luc, view all these changes of the land as having arisen from its subsidence into caverns; others who, like Hutton, consider that the effects have been produced by an elevating subterranean force; and a third party, who admit of both these modes and causes of motion.

It must not be imagined that the theory of the elevation of the land is limited either to that system, which is best known by the name of Dr Hutton, or to himself. It was originally proposed by Antonio Lazzaro Moro, and it has had many supporters among persons who never heard of an Huttonian theory. Nor is it limited to those who assign an igneous origin to certain rocks and certain changes; since it was the opinion of Saussure, than whom no one ever maintained more strenuously that theory which is called the aqueous or Neptunian.

It is not my intention here to enter into a critical examination of these theories. But it will not be irrelevant to remark, that the hypothesis which presumes on a subsidence of the sea, is singularly deficient in every thing requisite to explain the appearances for which it is invented to account; and that it cannot be reconciled to any thing that we know of the laws of nature. The angular and elevated positions of stratified rocks, and most particularly where they contain large and weighty fragments, could not have been produced by any mode of deposition from water. Neither could their fractures and dislocations. The positions of shells of various kinds in them, are equally inexplicable in the same view. Thus, where tubular living shellfish are now found, it is observed that their positions are always perpendicular to the horizon, and, consequently, to the stratum of sand which they inhabit. In a corresponding manner, empty concave shells must necessarily settle in water with their convexities downwards. Yet when the strata are found in elevated and angular positions, these shells retain that relation to the plane

of the stratum which they had when under the water; a sufficient proof of the displacement of these rocks.

The same theory, in assuming a disappearance of water, which must amount in bulk, at least, to the measure of the hollow sphere contained between that sphere which is measured by the least diameter of the earth, supposing it to be spherical, and by the greatest, imagines a case which cannot have existed consistently with all that we know of chemistry, of astronomy, or of the nature of the earth. Such a mass of water could not be destroyed; nor are any receptacles to be found, or even imagined for it. But it is not necessary to say more on this subject.

It remains to adopt some theory in which the land has been moved, or the rocks displaced, while the general mass of the ocean only changed its disposition in consequence of that motion. But, as it is not my intention to enter into the whole of this question, I shall merely state that the elevation of strata by an interior or subterranean force, must be admitted, at least to a share in these operations. The necessity of this is proved by a variety of phenomena which I cannot detail here. That such a force does exist, even now, is proved by the elevation of islands from the sea by the action of volcanoes, an occurrence which has often happened; and by the more common circumstances that attend these in ordinary cases, as in Italy, America, and elsewhere.

But this volcanic action has been supposed to be trifling and partial, and incapable of being resorted to for the solution of any other cases than those where the process has actually been witnessed, or can be clearly demonstrated. The object of this paper is to shew that it has produced far greater effects than has commonly been imagined, and that some of the most singular and interesting geological phenomena that are known, can be most satisfactorily explained in this manner.

Before describing the two cases which I have selected for examination, I must, however, notice the simpler one of ordinary volcanic islands, as illustrating the more complicated appearances under review. One of the most noted of these lies near Santorini, in the Greek Archipelago. The formation of this, in consequence of a submarine eruption, commenced in 1707, and in less than a year it had attained a circumference of five miles, with an altitude of forty feet. A similar one, of smaller dimensions, was also formed in the same place not long after; and, according to Pliny, Therasia,

no, and in a great measure by the numerous volcanic alluvia, or tufas, which, instead of remaining where they were erupted, have been transported and consolidated by water.

No blame, however, must be thrown on Signor Brocchi; his observations are, on the contrary, highly deserving of praise, as they are generally luminous, full, and well arranged, while they bear every mark of accuracy. It is no small proof of this, that I have scarcely any where found a chasm or uncertainty among them, though deprived of the advantage of re-examining the facts on the spot; while the evidence appears nearly as perfect and as well connected, though made without the advantage of a correct hypothesis, as if, with that theory in my hand which I here presume to give, I had examined them for myself. Had this excellent geologist paid more respect to the theory of his countryman, Lazzaro Moro, the task of explaining the facts which he has recorded would not have been left to another; but our science has long owed him a debt, which his successors, whether in Italy or elsewhere, seem to have been most unaccountably unwilling to acknowledge.

Those who may read these remarks, may probably feel some surprise that the late learned and keen illustrator of the Huttonian theory, who enjoyed the advantage of a personal examination of these appearances, did not come to the same conclusion as I have done; particularly as that conclusion must have appeared to him so valuable for his peculiar views of a geological theory. I do not pretend to account for the omission; though we must remember that the same appearances do not always make the same impression on every one. That omission must not, however, be urged as an argument against the theory which I have here adopted; since, without detracting from the high and acknowledged merits of Mr Playfair, every geologist is aware, that his exposition of his favorite system is often deficient in known evidence, as it is often also negligent of insurmountable objections.

In stating the facts from Signor Brocchi, I have been under the necessity of making a very severe abridgment; since, in a journal dedicated to original communications, it would have been improper to have occupied much space in detailing that which is already before the public. It is better to refer the reader to the work itself; and to it all will naturally have recourse, who may feel interested in the subject, and who are at the same time suspicious of the truth of the conclusions which I have attempted to draw. But I must repeat that I

have taken no liberty with the statements, as far as I have been able to apprehend their true nature from consulting both the treatises to which I have referred.

For the geographical details of the subapennine formation, I must inevitably refer to the work itself, as they would both occupy too much room, and would also be nearly unintelligible without a map. But it must be remarked, in a general way, that this deposit, as he has described it, is found, not only in many low situations, but forming a range of hills at the foot of the Apennine. Occurring thus in various places which I shall not enumerate, it is found, among others, in Piedmont, near Parma in Placentia, whence it extends all along the north side of this ridge to Otranto; while, on the south side, it skirts the elevated land in a similar manner, occurring at Orvieto, Rome, near Terracina, and elsewhere. I must also remark, that the same alluvia are to be seen near Vicenza and Verona, or at the foot of the Alps, as well as the Apennines; so that the term subapennine has not been very well chosen.

By putting together Signor Brocchi's facts, it is indeed easy to see that nearly the whole promontory of Italy is more or less covered by this interesting and remarkable deposit; that it does not necessarily form hills, and that it is deficient, only where its deficiencies may be accounted for, either by the waste of the superficial parts on the higher ridges of the fundamental mountains, and their consequent removal; or else by volcanic eruptions and earthquakes; or lastly, by the action of rivers, which have either washed it away, or have covered it with other alluvia of the usual recent terrestrial origin. It is important here thus to generalize these geographical facts, for which the materials have been furnished by the author.

The general alluvial deposit under review, as given by Signor Brocchi under a common term, consists of two beds, and it is highly essential to distinguish these where they are regular; because, as they are in some places much confused, they have been sometimes described in a careless manner, as if this was a part of their natural character. It will soon be seen that this confusion is the result of posterior, and sometimes of recent, causes. Where they have been described in this loose and general way, they have been said to consist of marl, sand, and gravel, together with sandstone and occasional breccias, containing further various marine and terrestrial remains. In a general sense, the beds may be consider-

ed horizontal, or rather as placed at low angles; and they are, consequently, unconformable, under the usual variations, to the inclined calcareous strata of the Apennines on which they lie.

The marl bed, which is the lowest, is, in some places, of an argillaceous nature; in others, argillo-calcareous; besides which it often contains mica. As it is sometimes wanting, the upper bed, which consists of sand and gravel principally, occasionally rests immediately on the solid and fundamental limestone. This lowest stratum is the repository of different mineral substances, such as the sulphats of lime, strontian, and barytes, flint, quartz crystals, pyrites, bog-iron ore, sulphur, and bitumen. Salt springs also rise out of it, and it occasionally gives vent to hot water and sulphuretted hydrogen; phenomena arising probably from the vicinity of volcanoes or volcanic materials.

To describe the upper bed more particularly, it consists of siliceous or siliceo-calcareous sand and gravel, often containing mica and yellow ochre, while in some places, as at San Marino and Volterra, it becomes a solid sandstone. It does not every where cover the marl bed, being occasionally deficient. This deposit, it may be added, is sometimes accompanied by the partial breccias just noticed, consisting of fragments of the older rocks, and occasionally containing shells.

If we take both these beds together, as Brocchi has sometimes done, from not seeing the value of the distinction, the organic remains contained in them exhibit great confusion of origin. They comprise numerous marine objects, consisting of shells and fishes; but these are far more abundant in the marl than in the sand, while very extensive tracts of alluvia are found without any. The shells are said to be sometimes similar in both beds; but it is very important to remark, that where they abound, they are found associated in families; a proof that they have not been transported, but that they now lie where they were originally produced.

Some of these animals, it must now be observed, are admitted to exist in the present seas of Italy, while others are supposed to be exotic or else unknown. Thus a great deal of additional obscurity has been introduced into this subject, which it is important to remove. As I cannot here however go into any great length of detail in this point, I must content myself with the case of Monte Bolca, as the most conspicuous example of erroneous observation and reasoning.

In this hill, the fishes are found in a marly slate, which is part of the lowest or marine bed, called by Brocchi subapennine. This substance does not lie in continuous strata, but in distinct and detached masses among the looser materials. The forms of these animals are well defined, particularly in the harder parts. The animal matter is indurated and mixed with the including earth, is of a brown colour, and is further, at times, so thick as to project from the stone, and to admit of being separated. This part is brittle and glossy, so as somewhat to resemble glue, but the bones are sometimes converted into calcareous spar.

With respect to the species, Volta, with a very imperfect knowledge of ichthyology, has thought fit to give names to one hundred and five, and has performed this task most incorrectly. Moreover, prejudiced in favour of some marvellous and mysterious revolutions of the globe, and like many other geologists, preferring an impossible solution to an obvious one, he has referred his imaginary species to various distant places of birth or habitation. Thus he begins by pointing out seven fresh-water fishes, as if he had not created difficulties enough without that; whereas Blainville, with an accurate knowledge of this subject, has decided that there is not one, but that they are all marine species. His testimony cannot be suspected of any bias, as he has no geological theory to serve, and has indeed committed this very error himself in the case of the petrified fishes of Oeningen. Among the remainder, Volta decides, generally mistaking either the genera or the species of both, that twenty-seven are European fishes, and thirty-nine Asiatic; that three belong to the African coast, eighteen to South America, and eleven to North America. Blainville very properly doubts this determination, on ichthyological grounds; and there need be no hesitation in saying that, on geological ones, it is impossible.

If the theory of Italy which I have to propose be correct, these should all be fishes that either reside now, or did once reside, in the Mediterranean; as there may be lost fishes as well as lost terrestrial animals. Accordingly, it is remarkable, that nearly all those which are so perfect as to admit of no dispute respecting their characters, are Mediterranean fish at present. Many specimens are so imperfect that it is impossible to decide on them; and Blainville, who is by no means wanting in good will towards the formation of species and genera out of imperfect fragments, has reduced the 105 to about 90. It is most evident, that a great part, even of this

number, is founded on the most random conjectures. But enough of Monte Bolca.

Besides the more common marine fossils, there are found the bones of whales and dolphins; and even entire skeletons of this nature have been discovered at elevations of 1200 feet above the sea. It is further remarkable, that the bones of the whales have been found incrusted with oyster-shells, and that they are almost always in a state of high preservation; a proof that they have not been brought from a distance, and a farther one that these are not transported alluvia.

The terrestrial remains are generally found a few feet beneath the surface, and are therefore commonly in the sand or gravel, or in the upper bed; but as that bed is occasionally absent, they also occur in the marl. They consist of the bones of the hippopotamus, elephant, rhinoceros, mastodon, urus, and elk, together with the horns of stags; and to these must be added vegetable remains, consisting of the trunks and fragments of trees, together with leaves but little altered, fresh-water shells, and, lastly, fragments of travertino, or alluvial rocks, and vegetable calcareous incrustations, resembling those which are daily formed in situations where solutions of carbonat of lime flow.

Besides these two remarkable beds, there are found, in many parts of Italy, superficial strata, some of which are peculiar to itself, while one is common to all countries. This last is the ordinary alluvium of rivers; such as that of the Po and the Adige to the northward of the Apennines, and that of the Tiber to the southward. Those which are peculiar to it, are the solid calcareous alluvial rock, called travertino, loose tufaceous matters of the same nature, and volcanic tufas. The plain of Sarteano, the Maremma of Tuscany, the Solfatara, and the vicinity of Rome, offer examples of these strata. The calcareous substances sometimes contain fresh-water shells and vegetables; nor are these always absent from the volcanic tufas.

Hence arises a confusion which requires to be explained, because it has very much obscured this subject. In his last work on Rome, Brocchi has cleared up some circumstances which he had not explained before; and it will shortly be seen that there is no difficulty in explaining the whole, and in simplifying the facts, merely by approximating and comparing them.

The chief confusion, in this part, consisted in the transportation of the volcanic substances, and in their cementation

by means of the calcareous waters which flow from the Apennines. In consequence of this they sometimes contain matters, the presence of which would otherwise be unaccountable; such as vegetables, and land or river shells. In the same way they alternate, or are strangely and irregularly intermixed, with the travertino and the loose alluvia of the river; while they are also found in places far from the vicinity of recent volcanoes, or from even the suspicion of ancient ones.

It is easy to comprehend the fallacies that must have arisen from misapprehending the real nature of these appearances. When also an opinion of their unintelligible derangement had once been adopted, much more confusion than was actually present was supposed to exist, where a little attention would have solved all the imaginary difficulties. Had Brocchi originally proceeded on a proper theory, there is little doubt that he would have found every thing easy, and have rendered it equally so to his readers.

According to this author, similar shells are sometimes found in both the alluvial beds; but it is moreover stated in a general way, that the more conspicuous marine remains occur in both. Yet, at the same time, it is said, and in a much more decided manner, that these are far more numerous in the marl bed than in the arenaceous one, and that the shells occur in colonies, just as they lived in the sea. It is also remarked, that the marine remains bear no marks of transportation; and further, that the terrestrial ones are generally found a few feet only beneath the surface, and in the upper bed; although, when that is absent, they occur in the lower. As that which I have undertaken to prove is, that the lower, or marl bed, is a marine alluvium, and the upper a terrestrial one, it is necessary to try to reconcile these anomalies, as well as that which consists in the confusion among the volcanic tufas and the alluvial substances.

The entire absence of all organic remains requires no explanation. Where the terrestrial alluvia are wanting, the organic substances that would otherwise be found in them, must necessarily appear to lie in the marine or lower stratum, however slightly covered or truly superficial they may be. Though found somewhat deeper, it is not difficult to understand how this might happen, as well as how the marine remains may occasionally occur in the upper alluvia. Revolutions of the surface, and principally from partial transportation by rivers, must inevitably have generated much confusion of this kind, capable, even in the hands of a good observer,

of misleading him in his conclusions, unless previously on his guard to distinguish appearances, which, even then, are often difficult to discriminate. Occasional marks of transportation might easily be overlooked over an enormous space, where the principal facts were of a different nature; as these latter would form a sort of standard for the whole, and would naturally lead to a neglect of such petty variations as seemed to be uninteresting. But geologists accustomed to investigation, are sufficiently aware of the ease with which errors of this kind are committed (particularly where no theory is present to point out what, appearing trifling, is truly essential) to feel no surprise at oversights of this nature, even in such a geologist as Brocchi.

That I may not, however, prolong this examination too far, I shall merely suggest two circumstances more, which may easily prove sources of error in reasoning about these Italian alluvia. It is far from certain, that the two beds can every where be distinguished, merely by their natures, exclusively of the remains which they contain. A sandy stratum must in some places have formed the bottom of the sea, as well as a muddy or marly one. Thus the marine alluvium may easily be confounded with the terrestrial one; beds of alluvial matter, not admitting of that separation which so generally marks different solid strata, even where the nature of the two beds in contact is the same. This is sufficiently obvious. It is also matter of notoriety, that volcanic eruptions and earthquakes have produced great confusion, even in recent times, in many parts of the surface of Italy; and when we consider the great number of ancient volcanoes in that country, sixty craters remaining in a very small tract, we need be at no loss in assigning abundant causes for disturbances and anomalies in the appearances of the superficial strata.

It is detracting nothing, therefore, from the merits of the Italian geologist to criticise his remarks; nor are his facts perverted, when they are thus rectified on acknowledged and obvious principles. The view here entertained of their real bearings is indeed amply confirmed by the great majority of the facts that are stated in his works; by which the distinction of two strata, one containing marine and the other terrestrial remains, is proved, even by himself. There is little doubt that had all the local circumstances attending each case, observed over so large a tract of country, been stated by this author, the present explanation would not have been required; nor would the point which it is my object to prove, have called for this discussion.

That point is, that Italy in general is covered by one marine stratum, in which the organic remains lie in an alluvial bed, untransported and undisturbed; and that above this there lies a terrestrial stratum which contains the remains of land animals analogous to those which are found in most other parts of Europe.

It remains to explain this state of things, or to give a theory of the alluvial deposits of Italy. That theory, if just, ought to be applicable to all similar cases of marine alluvia found high above the level of the sea, should such be hereafter discovered in other places; and it will thus furnish us with a new key for the solution of a certain set of geological phenomena, for which no other branch of any of the general theories provides an adequate explanation. It is important to remark how accurately this partial theory ramifies from the general one, which accounts for the elevation of the strata by a subterranean force; and how valuable a test of any theory it is, to be thus provided with the means of explaining appearances that could not have been anticipated when it was formed. Had Lazzaro Moro taken a wider and more accurate view of the circumstances by which he was surrounded, the present explanation would not have been required.

In investigating the causes of the present positions of solid rocks containing organic remains, we are only enabled to assign them in a general manner, and by analogy, because they have left no positive collateral evidence of their action. This may probably be in a great measure attributed to the great distance of these events in point of time, and to the changes which the exposed surface of the earth has since undergone. In the present case, however, we see the germs of these very submarine strata exposed before their consolidation, and probably presenting the appearances which they do, merely because they are of more recent date. At the same time, instead of being driven to seek for causes by a circuitous and analogical road, we find these at hand in the general volcanic nature of the country under review, while, in some places, we can almost trace the very cause itself in action.

In different places, and in Italy very particularly, it has been observed, that the relative level of the sea and land is subject to change, and that it has in past times undergone frequent alterations. For the proofs and nature of these, I must refer to Breislak and others, who have examined this subject with considerable care, as I dare not prolong this paper by repeating them. The present case may be considered as an

extreme one of that nature; in consequence of which the bottom of the sea, together with its unconsolidated alluvia has been raised above the surface of the water, so as to have become dry land. Thus it is easy to account for the presence of marine remains, as well as for their presence in that singularly undisturbed state which has been described.

It is equally easy to account for the proximity of the marine and the terrestrial remains, as also for that of the alluvia which respectively enclose each. Whatever cause or causes generated the usual terrestrial alluvia that occur all over the world, these have apparently been deposited, in most cases, on naked rock. In this particular one, they have settled on a previous alluvium of a different character, and, as far as our present imperfect observations go, solitary. The apparent interference of the two classes of organic remains follows of course.

If that interference is ever greater, so as to amount to a real mixture or alternation, I have already shewn how it can be explained, by a variety of circumstances, consisting in more recent changes and deposits, and in the imperfection of observations, the real bearings and value of which were not anticipated. But it is proper also to say here, that other causes of a more general nature may have produced the same effects without in any degree vitiating the theory here offered.

It is believed that many of the terrestrial alluvia have been the produce of diluvian currents; and it is impossible, if this be true, that these should have taken place without disturbing a previous alluvium. Thus the mixtures of the different kinds of remains would be accounted for, even in those cases where they could not be attributed to the modern action of rivers.

Although no real instances of alternation in these alluvia have been brought forward, and as a true one, could not indeed happen, it is also easy to see that such an event might occur upon the same principles which have produced the alternation of marine and fresh water deposits in the basin of Paris, or in the other tertiary formations. It is equally easy to comprehend that, in such a case, a mind unprepared for a proper examination of the appearances, might be led to confound together, things differing in their natures, and thus to throw doubt and confusion into that, which, if rightly examined, would present no real difficulty.

It now follows that the elevation of the land of Italy, which is the origin of these phenomena, is to be attributed to the

same causes which are now, or have recently been, operating in producing smaller changes in the relative level of the sea and land, and of course, in elevating the latter. These causes are connected with earthquakes and volcanoes, or are dependant on volcanic action. They are the same that raised Santorini from beneath the ocean, and that have produced the phenomena of the coral islands, which will shortly be described. In the history of these, further proofs and confirmations of these views will be found. Of whatever date these events may be, they are anterior to all history; even to that of the general deluge, if it is rightly judged that any of the terrestrial alluvia were deposited at that period. If a similar occurrence were to take place at present, it is evident, that the submarine alluvial stratum with all its imbedded remains, would exhibit the same appearances as the lowest of the Italian beds does; and that the skeletons of whales should be found at elevations of 1200 feet above the level of the sea, is no more surprising than that they should be found at all.

This particular fact is, however, important, as shewing the vertical extent of this elevation, just as the geography of the marine remains demonstrates that of its superficial one. For want of more accurate information, we may here take these as Signor Brocchi has given them, for the extreme limits both ways; and thus we can estimate what Italy was before the change, and how much of it has been the consequence of a volcanic elevation more recent than those extensive changes of the same nature which caused and determined the present general distribution of the land.

The extreme height of the Apennines is said to be about 9000 feet, and, on the present supposition, the whole of that chain, from this height down to that of 1200, must be supposed to have formed a ridge rising above the sea. I need not extend these conjectures to the side of the Alps, as the reader can easily pursue these speculations at his leisure. It is probable, that at the period at which modern Italy was produced, the whole of the central chain experienced a fresh elevation to the altitude of at least 1200 feet, and over a superficial space which reaches from Otranto at one end of the country to Piedmont, and to the foot of the Alps generally, on the other side; since the neighbourhood of Vicenza and Verona presents the same appearances.

Others may imagine, if they please, that only those parts were thus elevated which now possess the submarine alluvium; yet this would make no difference in the general views; since

that force which was sufficient to move so large a part of Italy might as easily have moved the whole. This is a circumstance that might however be put to the proof, by examining the stratification of the Apennines in a proper manner. Some dislocation or discontinuity in the order of the stratification will be found at a certain elevation, if this supposition be correct; and I may here point out to those geologists who may have an opportunity, the interesting circumstances of various kinds, which still await them in Italy, from the views of the nature of that country which I have here given. Were it of any use to accumulate conjectures, it might even be suggested that the whole of that country, even to the highest point of the Apennines, was raised at one single period from beneath that ocean in which we know that the limestone of this ridge was formed. Should this have been the case, the absence of the marine alluvium from the higher parts, would be accounted for, on the same principles which are applied to the denudations of the earth's surface all over the world.

Though these phenomena should be quite partial, and if they do not, therefore, possess so high an interest in reality, as the great elevations of the continents, and of the enormous mountain chains of America or Asia, they are of a much more impressive character, from the greater facility with which we associate the causes and the effects, and from the more palpable and tangible nature of the phenomena; from the actual association of an active existing cause, with effects that cannot be questioned. The others we look coldly at, through the lapse of ages incalculably distant; so distant that they excite in us no personal interest, and so much less obvious also, that we feel rather inclined to doubt, than to admit of conclusions which are attended by consequences somewhat revolting to our narrow experience. In contemplating the others we feel the insecurity of the earth on which we stand, and in every earthquake recollect that what once arose, may again be consigned to the bottom of the ocean.

Before concluding this subject, it is necessary to remind the reader of one collateral circumstance, which is not only interesting in itself, but which strongly confirms those views of the cause of those appearances which I have here held out. That is, the suddenness or rapidity of the action which produced these important events. This might be concluded from the undisturbed state of some of the shells and skeletons already mentioned; but it is still more strongly proved by the preservation of the animal matter in the ligaments of the

bi-valves, and by the condition of the fishes of Monte Bolca already mentioned. A noted specimen, now in the collection at Paris, and once appertaining to Count Gazzola, evinces in a singular manner the rapidity of the catastrophe by which these changes were effected; since, in it, one fish appears to have been arrested in the act of swallowing another.

It will not here be superfluous further to observe, that the condition of the fossil fishes of Iceland, seems to throw light on the remarkable deposit of Monte Bolca. These are found at Patrick's Fiord in that country, imbedded in an indurated mud, or marl, and it is said that they are even now in the act of being formed. The fish, in a living state, or perhaps but just dead, seems to have been first entangled in a soft mud, which has been firmly attached to it by means of the animal matter that has mixed itself with that substance; while the harder parts, of the bones and scales, remain unchanged. Thus the nodule that encloses them is first produced, and it remains imbedded in the surrounding materials.

I may now terminate this part of the present subject, as that which follows pursues the same train of reasoning on a different foundation of facts. But I must not quit it without pointing out to geologists, the propriety of examining all the situations analogous to Italy, since the same circumstances respecting the alluvia may possibly exist in many other places. That part of the subject has been entirely neglected; although volcanic regions and volcanic phenomena have been far from deficient in observers. The present case offers an apt instance to illustrate the necessity of previous theories or general views. Without such a guide, these obscure appearances might easily have continued to be misapprehended, so as to have deprived us of a most valuable evidence respecting the changes of the earth's surface and their causes.

It is scarcely necessary to point out the places where such phenomena may be sought for; although, as being the most easy of access, and as presenting the most satisfactory examples of volcanic elevation, I may name the Azores and the other volcanic islands of the African coast, as well as St. Helena, Ascension, and perhaps, Owhyhee. It ought also to be in the perpetual recollection of every geologist, that as all the supramarine land has apparently been elevated by some causes, from the bottom of the sea, there may be submarine alluvia beneath terrestrial ones, in many countries which shew no traces of a volcanic nature, or of a volcanic origin.

The general importance of this remark must be very apparent. It is quite possible that this may have been the true

source of many of the appearances connected with alluvia and with fossil remains of different origins, that have been the causes of so much trouble to observers. It must be remembered, that although all the land be supposed to have been elevated from the sea, it by no means follows, that this was a single event. It is much more probable that it was successive, and that the causes operated through a long series of ages. Hence there may be a chain of intervals in time, connecting the most remote catastrophes of this nature with that of Italy, and uniting even this one with the latest formations of volcanic islands. Among some of these, at least, we might expect to find analogous appearances to those which have here been discussed; as it is impossible to conceive an elevation of rocks which was not accompanied by that also of the unconsolidated submarine materials that chanced to be present. I will not, however, dwell on this suggestion; as I know not of any positive observations at this moment that could be brought to bear on it. Yet geologists must see that they have been somewhat hasty in limiting the causes of alluvia to diluvian operations, or to those more tedious actions which form so conspicuous a part of one of the most noted theories of the earth.

(To be continued.)

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ART. VI.—*Account of the Sepulchral Caverns of Egypt.* By COLONEL STRATON, C. B. 6th Dragoons. Communicated by the Author. [*Edin. Phil. Jour.*]

THE Lybian chain of rocky mountains borders the western side of the Nile, and the Djibel Mokattem, the eastern side, sometimes approaching close to the river, and at other times receding to a distance of several miles.

At Thebes, the cultivated plain is very extensive on the eastern, while it is more limited on the western bank, and, on both, the country is extremely fertile; the dourra, or large millet (Holcus Durra,) attaining the height of six feet*.

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* It is the staple of the country: the bread is made from it.

On the western side, the rock is excavated into sepulchral caverns, forming the Necropolis of ancient Thebes, and now very generally occupied as dwellings by the population of the village of El Gournou. Some of these catacombs have a covered entrance, or vestibule, cut out of the rock, leading to a gallery, with mummy-pits on both sides, and at the extremity. In others there is no porch, but a descent, either perpendicular, on an inclined plane, or by steps in the rock, to a painted chamber, containing sometimes a few mummies, the greater part being deposited in pits, which are more sunk than the chamber. In the descending passage, as well as in the chamber, the sides and ceiling are polished as highly as wrought marble: The stone thus polished is remarkably white, and frequently is covered with a stucco quite as fine as plaster of Paris, of the most dazzling whiteness, and often, but not always, highly varnished. On the sides or walls thus prepared, are represented the feats of a hero, scenes drawn from the agriculture, manufactures, commerce, sports and amusements of the ancient Egyptians; or, we find representations illustrating their progress, in those remote periods, in the arts, the sciences, and in the luxuries, refinements, and elegancies of life, or depicting a wide range in mythology, from which the Greeks and Romans have borrowed largely. These pictured representations are intaglios, relievos, or painted on the surface: the colours are, from the almost complete exclusion of the atmospheric air, in many sepulchres, as vivid as if recently laid on; in all, the tincts most subject to fade, are, from the aridity of the climate, clearly discernible. The ceilings are not unusually painted in small squares, somewhat like the painted flooring-cloth used in halls and lobbies.

The mummy-*pits* are generally roundish in shape, with the sides and ceiling rough. The mummies are enveloped in numerous folds of a sort of linen stuff, impregnated with gummy and resinous matter; the most common sort have no other covering: a second class has a covering of cement or stucco upon canvas, made to adjust itself to the body, and painted with figures and hieroglyphics,—a human face, probably that of the deceased, is frequently painted on the case: a third class of mummies, thus doubly enveloped, are laid in a wooden case, sometimes thin, at other times of very considerable thickness, and more or less ornamented with paintings. The upper part of the case is furnished with wooden pegs, and the under with holes to receive them; while some are further se-

cured by cross pegs. The wood is generally in perfect preservation, and I believe invariably of sycamore; pieces of date-tree are found in the caverns, but on handling them, they crumble to dust. The mummy cases are also found immersed in bituminous matter, so adhesive, that in removing them, the bottom part remained in the preparation*.

All the mummies were laid horizontally; though Dr Shaw, I think, says they were placed perpendicularly. The horizontal position is further confirmed by the pictured representations of mummies in the sepulchres. The male mummies had generally the hands placed over the middle; the female across the chest.

The entrance to the newly discovered caverns, was found barricadoed by a wall, and covered up with heaps of stones. Barriers of stones or of the rock are also found in the galleries, and the passage intersected with a deep cavity.

The sepulchres in the valley of Biban el Moluk (called the Tombs of the Kings), at the distance of seven or eight miles from the western bank of the Nile, are much more extensive, and infinitely more magnificent. Many of them contain a sarcophagus of granite, and one has a sarcophagus of alabaster. In the cavern where the dancing girls are painted on the walls, the first figure, on entering, is a male harper sitting, as is still the practice in these countries, with his legs across: his head is shaved; and the harp has nine strings. Then follows the group of dancing girls. The upper part of the dress is red, and resembles hair; the lower part is white and transparent, without any folds. On a pannel above, in the same room, there is a row of five females seated, some on camp stools, others on chairs with four legs. Each of these females holds a lotus flower in the right hand, turned towards the nose, and the left hand rests on the knee. In the pannel under the dancers, is another row of seated females; the hair is matted, thickened, and made wig-like, with grease or oil, exactly as the Nubians of the present day wear the hair†.

On the adjoining wall is a seated female, having on her knee a young boy, his face turned towards her, holding the

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* A very perfect mummy from Thebes, was presented to the University Museum of Edinburgh by Colonel Straton.—*Ed. E. P. J.*

† I have been told, that the oil used for thickening the hair is obtained from the oily grain of the sesamum, (Sesamum Indicum,) which abounds; it serves to protect the head from the sun.

crook in his right hand, and the sacred Tor in the left, with a figure of the Scarabæus suspended from his neck, like the Bulla worn by the Roman youth of distinction. From the attributes, it is probably meant to represent Isis and Orus.

On another wall are two harpers cross legged. One of the harps has seven, and the other fourteen strings.

The Almé, or dancing girls of the present day, make use of the same instruments with the exception of the harp, which is unknown to the present inhabitants of Egypt. A mummy-pit adjoins the chambers, containing several mummies in a tolerable state of preservation, but none of them were in cases. They were all in linen, which was wrapped round in vast quantities; this linen had a border and fringe, and was, as well as the thread, in perfect preservation. I had been assured that rolls of papyrus were often found under the arm-pits, or between the thighs of the mummy, but here I looked for it in vain. I bought some rolls from peasants, who asserted that they found it thus placed. Some sandals were also brought to us, found in a sepulchre: one pair was very perfect, the upper part green, and the toe turned up, like the present Turkish slipper. The sole consisted of three distinct layers of whitish tough leather, resembling chamois. The sewing and stitching was very neatly executed; whitish thongs, nicely plaited, were attached to the sole. The figures in the sepulchres and temples are, however, generally barefooted, and I observe only one instance, where I have noted them having sandals on the feet.

In another sepulchre, 22 yards long by 21, is represented a figure, probably a Deity, with a very high cap, holding a rod (the *hasta pura* of the Romans,) in both hands: a female figure presents to him a leg of the gazelle*. The cap is yellow, the dress white, with a yellow scarf over the shoulder, and bracelets and armlets of gold. The female wears a white dress, the under part of thin transparent stuff, like muslin or gauze; the skin, always painted reddish, appears through it. Her eyes are black, rendered larger to appearance, and elongated at the corners, by means of black paint. At present, the females of this country, and even sometimes men, dye the eyebrows with galena or lead-glance, called in the Levant Alquifoux; it is reduced to a fine powder, and mixed up with the fuliginous vapour of a lamp. The eye-

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* Presentations of parts of animals, birds, bread, flowers, libations, &c. &c. are very common.

brows and eye-lids are painted, and the lashes are blackened, with a reed or quill, which is passed lightly between the eye-lids. The angles of the eye are also tinged, and prolonged, which makes it appear larger and more oblong. The ancient Egyptian ladies in many instances, and the men, in one, (at Ipsambul,) are represented as having resorted to the same arts of the toilette. Juvenal satirizes the Roman ladies for this coquetry :

> " Illa supercilium, madida fuligine tactum,
> " Obliqua producit acu, pingitque, trementes
> " Attollens oculos." Juv. Sat. ii. l. 93.

In these sepulchral caverns, are frequently found small brooms, of the stuff of which we make mats ; small figures of the human body, sometimes with the human head, at other times with the head of a cat, dog, scarabæus, &c. &c. These caverns have been selected for description, not on account of their extent or interest, but solely from their not having been known to former travellers.

The following is a description of the Mummy-pits at Thebes from the Narrative of Operations and Discoveries in Egypt, by M. Belzoni.*

The passage where the bodies are is roughly cut in the rocks, and the falling of the sand from the ceiling of the passage causes it to be nearly filled up. In some places there is not more than a foot left, which you must pass through, creeping like a snail on pointed stones that cut like glass. After getting through these passages, some of them 200 or 300 yards long, you generally find a more commodious place, perhaps high enough to sit. But what a place of rest! surrounded by bodies, by heaps of mummies in all directions, which impressed me with horror. The blackness of the wall, the faint light given by the candles and torches for want of air, the different objects that surrounded me seeming to converse with each other, and the Arabs with the candles or torches in their hands, naked, and covered with dust, themselves resembling living mummies, formed a scene that cannot be described. After the exertion of entering into such a place, through a passage of 80, 100, 300, or perhaps 600 yards, nearly overcome, I sought a resting-place, I found one;

* We hope, in our next number, to lay before our readers a description and account of the Mummy lately received in this city from Thebes.
*Ed. B. J.*

and contrived to sit; but when my weight bore on the body of an Egyptian, it crushed in like a bandbox. I instantly had recourse to my hands to sustain my weight, but they found no better support, so that I sunk altogether among the broken mummies with a crash of bones, rags, and wooden cases, which raised such a dust as kept me motionless for a quarter of an hour waiting till it subsided again. I could not remove from the place, however, without increasing it, and every step I took I crushed a mummy in some part or other. Once I was conducted through a passage no wider than that of the body, and choked with mummies, and I could not pass without putting my face in contact with some decaying Egyptian; but as the passage inclined downwards, my own weight helped me on; however, I could not avoid being covered with bones, legs, arms, and heads rolling from above. Thus, I proceeded, from one cave to another, all full of mummies, piled up in various ways, some standing, some lying, and some on their heads.

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## Art. VII.—*Geology and Mineralogy of Ceylon.* [J. W. W.]

The second part of the 5th vol. of the Transactions of the Geological Society of London contains an interesting letter from Dr John Davy, describing the geological structure and mineralogical productions of the island of Ceylon. We have been induced to make an abstract of this communication for the benefit of our mineralogical readers, who have not access to the work itself.

The island appears to be one mass of primitive rock, connected with but one rock of later formation. The primitive mass varies in height from 500 to 7000 feet, the elevation of Adams peak the highest point in Ceylon. The southern part of the island is the most elevated; the shores are shelving. The hills and mountains are conical, peaked, craggy and tabular, and their direction is various. The whole formation bears marks of great antiquity, and the accumulation of debris and alluvium "proves that the degradation of the heights has been very great." The same is true in regard to the low country.

The soil is generally poor, containing but a small proportion of vegetable matter, seldom more than one or two per

cent. Notwithstanding this the interior teems with vegetation, which Dr Davy principally attributes to the "high temperature of a tropical sun, and the abundance of water in a mountainous region."

The vallies are narrow and deep; they have always an outlet, in consequence of which there are no lakes, a remarkable circumstance in so large an island. Artificial lakes have been formed for agricultural purposes "by immense, almost incredible, human exertions; or by the effect of the sea, in throwing up sand banks and stopping the natural exit of the waters."

The formation of salt in some of these lakes, has been considered, observes Dr Davy, a mystery by many, but it was ascertained that the salt is derived from the sea water which occasionally overruns the banks.

The scenery of the country is beautiful and sublime; and nature with "a liberal hand, has scattered charms over this fortunate island."

The predominant rock in Ceylon appears to be gneiss; granite is but rarely met with. Graphic granite of great beauty was found at Trincomalie, about half a mile beyond Chapel point.

Sienite occurs in several places. Felspar is common, but the adularia variety was met with only in one place, amongst the mountains of Doonberava. Greenstone was found in the neighbourhood of Kandy and Trincomalie; and of this rock Adams peak is partly composed.

The veins of quartz in the gneiss are so large as sometimes to rival mountain masses, extending in one instance a distance of two miles. "These quartz rocks stand erect, like denuded veins, very precipitous, and often exhibiting the appearance of buildings in ruins." The quartz is milk white, translucent and very friable.

In addition to these which Dr Davy considers as the principal varieties of the gneiss, there is another containing calcareous spar. The last variety occurs abundantly in the Kandian country, where nitre is manufactured. The principal nitre work is thus described. "It is a large cave in the side of a great precipice, which is situated in the depth of an immense forest surrounded by mountains in a remote part of Doonberava. The cave is about 200 feet deep, and its mouth is about 100 feet high by 80 feet wide. The rock in which it occurs is an intimate mixture of quartz, felspar, calcareous spar, and mica, with here and there talc and some other

minerals. Wherever it is exposed to the air the rock is impregnated with nitre; and not merely at the surface, but as deep as air can penetrate, but no further. Besides nitre, I may remark, the rock contains other salts, as nitrate of lime, sulphate of magnesia, and alum." The apparatus employed by the Kandian workmen is rude, and in their operations they exhibit much skill on some points and great ignorance on others. Wood ashes, for example, are sagaciously added to decompose the nitrate of lime, and after being at great pains to purify the nitre by picking out the crystals of sulphate of magnesia, they ignorantly throw away this latter salt. The persons of the workmen are savage, their bodies are almost naked; their hair is matted, their beards long, and their minds correspond to their forms. They are superstitious and ignorant, sacrificing to demons, and offering them their best refined nitre to propitiate their favour.

Dr Davy next proceeds to describe the minerals found in the gneiss. Iron appears to be the only ore of a common metal hitherto discovered in Ceylon, and it is pretty abundant. It occurs imbedded in the gneiss under the forms of pyrites, magnetic, and specular ore, and red hematite; bog iron ore, and the earthy blue phosphate of more recent formation are also found. "The red hematite and the bog iron ore are the most abundant, and it is from these ores the natives usually obtain the iron which they use." The reader is referred to the history of Ceylon by Knox for a faithful account of the Kandian process of smelting these ores.

Dr Davy found no traces of other metals, and the result of his inquiries is, that the assertion that gold and mercury are found in Ceylon, is completely erroneous.

The rare and valuable gems constitute the principal mineral riches of this island; Dr Davy is of opinion that most of the gems for which Ceylon has been celebrated, were originally imbedded in gneiss. This opinion is derived from the quality of the alluvium in which they occur, and from the nature of the adjoining rocks, for they are seldom found in their native rock.

The minerals discovered by Dr Davy in the gneiss, or which he conceives to have once been contained in it, are many of the quartz family, as rock crystal, rose quartz, cats eye, prase and common quartz. The rock crystal is so abundant that it is used for ornamental purposes, in statuary, and instead of glass for spectacles. In the great temple of Kandy is a well executed crystal figure of their god Booddo.

The cats eyes of Ceylon are well known to be the finest in the world, the best specimens are found in the gneiss alluvium in Saffragam and Matura. The rarest variety of quartz in Ceylon is hyalite, it was met with only in the great nitre cave in Doonberava, incrusting a rock, and closely resembling the siliceous deposits of the geysers of Iceland.

Topaz and schorl are the only two species of the schorl family of the occurrence of which in Ceylon there is no doubt. The former is commonly distinguished in the island by the name of white sapphire; "it is generally white or very pale blue or yellow," and occurs in the gneiss alluvion. Common schorl appears to be tolerably abundant in the gneiss, but tourmaline is rare; the only variety which Dr Davy met with is the honey yellow. Dr Davy is doubtful of the existence of emerald and beryl in Ceylon, and is disposed to believe that all the beryls sold in the island are imported.

The gneiss contains three species of the garnet family, viz. the garnet, pyrope and cinnamon stone; the first is abundant; the best crystals occur in quartz rock. The second is found only in small quantity in decomposing gneiss, at Matura. Of cinnamon stone, although abundant, but two localities are given, Cotta, and Belligam; at the former place it is found in gneiss alluvion, at the latter it enters into the composition of "a large detached rock with felspar, quartz, hornblende, and graphite."

Of all minerals, those of the zircon family are the most numerous. It is most abundant in the district of Matura, as is indicated by the popular name, "Matura diamond," which the dealers apply to the finest varieties. Besides the common zircon and hyacinth, Dr Davy met with pieces of a third variety, some of which weigh two or three ounces; it is opaque, amorphous and of a dark brown colour. Another mineral, apparently of the same family, is described as black, opaque, of small conchoidal fracture, and vitro-resinous lustre, hard, of high specific gravity, in general amorphous, rarely crystallized, the crystals being imperfect four sided prisms acuminated by four sided pyramids. The natives of Ceylon are perfectly ignorant of the true nature of zircon, and sell the yellow varieties as topazes of a peculiar kind, the green as tourmalins, the red as rubies, and the light grey as diamonds. All the varieties brought to market are found in the beds of rivers, or in alluvial soil; and this appears to have one general character which indicates its origin from gneiss.

The only places where Dr Davy discovered zircon in its natural situation are, a small island in Belligam bay, and a

few miles from Belligam. On the former spot, it is sparingly disseminated through a rock consisting chiefly of quartz and schorl. At the latter, it occurs abundantly in a rock composed of quartz and adularia; the zircon in some parts of the mass is in such large proportion, that the rock almost deserves the name of zircon rock. "The mineral in this instance is crystalline, and most commonly green or brown; the rock is remarkable for its specific gravity and the resinous lustre of its fracture."

Spinell, sapphire, and corundum, for which Ceylon is celebrated, occur in the gneiss. The first is comparatively rare; but was likewise found in a variety of clay iron ore. The second is far more abundant. All the varieties of sapphire, observes Dr Davy, occur in perfection in this island, as the blue, red, yellow, green, white, and star stone—the green is very rare. "Corundum is less frequently met with than sapphire. I know of one place only where it abounds in the island; it is a spot called Battagamunna, near Atala in the province of Uwa. It is collected and brought to Kandy as an article of revenue; the specimens of it I have examined are either irregular masses, or crystallized in the form of low six sided prisms. I have not yet been into Uwa; but from the specimens of the rocks that I have procured from that quarter, and from all the information I can collect, I have little or no doubt that the matrix of this mineral is gneiss, on a granite rock."

Dr Davy notices specimens indicating a transition from sapphire to corundum.

Of the chrysoberyl, which, from various authorities had always been supposed common in the sand of the rivers of Ceylon, no specimens were met with. Dr Davy expresses, however, his conviction that the mineral occurs there.

Many varieties of felspar are enumerated. Common hornblende is abundant, entering into the composition of some of the rocks. Tremolite is found only at Trincomalie in a narrow vein in gneiss. A small vein of pitchstone was observed in granite. Mica is abundant as an ingredient of the gneiss. Chlorite is occasionally seen, but talc is rare.

Of the calcareous minerals two only were noticed in the gneiss, *viz.* calc spar and anhydrite. In the nitre cave they occur finely crystallized. Graphite is the only mineral of the inflammable class which was observed, and it is disseminated in minute scales through the gneiss. "It is worthy of remark," continues Dr Davy, "that graphite is generally

found in company with gems. I have had so often occasion to make the observation, that now I never see the former without suspecting the presence of the latter."

The assertion that sulphur is found in Ceylon is not supported by the information collected by Dr Davy, and he thinks there is good reason to believe that the sulphur, formerly employed by the Kandians in the manufacture of gunpowder, was secretly procured from the continent of India by means of pilgrims going to Adams peak.

The other primitive rock of Ceylon is the dolomite and the only parts of the country where it forms hills is in Matele, a province between Kandie and Trincomalie, and in the neighbourhood of Hangrankketty, a few miles to the east of Kandy. It sometimes appears in the form of veins. The only metal detected in it was iron, and the only minerals were mica, apatite, clay, apparently derived from the decomposition of felspar, graphite, ceylanite, and a bright yellow substance which Dr Davy conceives to be a new variety of cinnamon stone. Ceylanite is the most abundant and occurs crystallized and amorphous, of various colours, bright azure blue, violet, pink red, grey, and white. Calc sinter, calc tuff, and agaric mineral are also found associated with the dolomite.

The rock of recent formation alluded to in the first part of this paper is a sand-stone, and occurs on the shores in extensive horizontal beds, in many places below high water mark. This rock is hard and compact, with a light yellow or grey colour. It consists of siliceous sand and minute fragments of shells. The cementing principle was not ascertained; we are informed, however, that it is *not* iron. "It is remarkable that this rock does not form in sheltered situations; on the contrary where the sea breaks with uncommon violence. From the composition of the rock and its situation, there is good reason to believe not only that it is very recent, but that the process of consolidation is still going on."

In regard to volcanic rocks, and the indications of volcanic action in Ceylon, Dr Davy observes, he has often sought for them, but without success. "Trincomalie is the only part of the island that I have yet seen that excites even the suspicion of volcanic action. I have mentioned one circumstance that may lead to this suspicion, viz. the hot wells of Cannia; and I have alluded to another, which is striking, at Trincomalie, viz. the peculiarities of the bay and shores; the bay, very near land, being unfathomable in many places, and the shores in

general very precipitous, whilst the surrounding land is comparatively low. But these phenomena are very slight indications of the action in question, and I am not aware that there are any other."

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## Art. VIII.—*On the Luminous Appearance of the Ocean.*

The luminous appearance of the waters of the ocean has always excited the attention of voyagers and naturalists. Many observations have been recorded, and various theories proposed for the solution of this curious problem. From the investigations of Professor Macartney and others, the most satisfactory explanation has at length been obtained. There is now no doubt, says Dr Roget, that "the phenomena in question are most frequently occasioned by the presence of a very minute animal of the genus zoophyte, to which the name of medusa scintillans, has been given. The individual animals are smaller than the head of the smallest pin, and are so transparent as not to be distinguished, without great difficulty from the water in which they swim. Various other marine zoophytes are also mentioned as contributing to this luminous appearance.

"The process by which the light is emitted appears to differ altogether from that of slow combustion, which, in the case of phosphorus, produces similar appearances; and to be connected with some vital action accompanying the movement of the animal, and resulting from some voluntary effort. They are not only independent of all foreign light, but generally cease when any other luminous body is present. Thus the shining of the medusæ ceases upon the rising of the moon, or the approach of day.

"When taken from the sea and kept in vessels for the purpose of examination, these animalcules can never be excited to throw out light, unless they have been previously kept for some time in the dark. The luminous property is not constant, but exists only at certain intervals and in particular states of the animal, and appears to reside in a particular fluid secretion."

The following account of this appearance is extracted from a manuscript Journal of a gentleman of Boston, kept on board the ship Canton, on a voyage to India in the year 1816.

"August 20th, S. lat. 9° 8', and E. long. 105° 45', at 6 o'clock, P. M. the water along-side became somewhat coloured. Having had two lunar observations this day, we were under no apprehension of land being near. At 8 o'clock, very suddenly, the water in every direction became as white as lime. Tacked ship. In about half an hour the water changed to somewhat of a greenish colour; soon after, the horizon ahead was lighted up. We soon discovered it was occasioned by this unaccountable white water, now extended again on all sides of us. As we had sounded in the first part of 8 o'clock, and it being now 9 o'clock; and as we had run back to where we left the water but a very little coloured, but now become like cream, we concluded that we could not be running over a shoal.

"The weather was clear, and not a cloud to be seen, of any consequence, all night.

"21st, A. M. (shore time), at 1 o'clock we stood on our course again; at day light the water became clear. All this may be common, but no person on board ever saw the like before. The water was as white as cream, and apparently thick, but on being brought to the candle it was as clear as any sea water. This must have been in S. lat. 10° 10', and E. long. 105° 20'."

Nearly the same appearance was observed by captain Tuckey, (see his narrative p. 49,) after passing Cape Palmas and entering the Gulf of Guinea; and the whiteness of the sea gradually increased till they made Princes Island. At night the ship seemed to be sailing in a sea of milk. In order to discover the cause of these appearances, a bag of bunting, having its mouth extended by a hoop, was kept overboard; and vast numbers of animals of various kinds, particularly pellucid scalpæ, with innumerable little crustaceous animals of the scyllarus genus attached to them, were collected. Thirteen species of cancer were caught, not above one-fourth of an inch long, eight having the shape of crabs, and five that of shrimps. Among these the cancer fulgens was conspicuous. On examining another species by the microscope, in candle light, the luminous property was observed to reside in the brain, which, when the animal was at rest, resembled a most brilliant amethyst, about the size of a large pin's head; and from this there darted, when the animal moved, flashes of a brilliant silvery light*.

* Captain Scoresby, in an interesting paper in the Edinburgh Philosophical Journal, has described a peculiar appearance of the Greenland sea, produced

The following is extracted from the Edinburgh Philosophical Journal, No. 14.

The Memoirs of the Academy of Sciences (Savans Etrang. tom. iii. p. 267.) contain the observations of Godeheu de Riville on two minute marine animals, one of which is very remarkable for its phosphorescent qualities. It is not, strictly speaking, an insect, but belongs to that subclass of the crustacea, called entomostraca, by the French naturalists. Latreille regards it as falling under the genus lynceus, of Muller, which is one of the many necessary generic branches of the Linnæan monoculus.

"Among the various phenomena," says the author alluded to, "of which the causes are still almost unknown, that starry brightness, which we so often perceive in the slightly agitated waters of the ocean, greatly merits the attention of those who have a taste for physics; but I have not yet read any thing satisfactory on the subject, as writers seem to have satisfied themselves rather with conjectural reasons, than by making experiments to ascertain the real origin of this natural phosphorus."

During a voyage made by our author to the East Indies, he was enabled to make the following observations: About 9 in the evening of the 14th July, 1754, being in N. lat. 8° 47′, and E. long. 73°, from Paris, he was informed that the sea appeared like a sheet of fire. Every portion of its surface, when gently agitated, broke into a thousand stars. Each wave which coursed along the side of the vessel, spread out a pure, shining, silvery light. The more distant swelling of the waters presented the appearance of a moving plain covered with snow, and the wake of the vessel was of a clear and luminous white, sprinkled over with brilliant spots of azure light (*azurés.*)

"Anxious," he continues, "to consider a spectacle, to me alike novel and interesting, I was struck by the light shed by certain small bodies, which frequently remained attached to

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by animalcules of a lemon yellow colour, and globular form. The surface of the sea was variegated by large patches, and extensive streaks of a yellowish green colour; having the appearance of an admixture with flowers of sulpher or mustard. In a drop of the water, examined by a power of 28,224 magnified superfices, Capt. S. discovered, on an average, 50 animalcules in each square of the micrometer glass of 1-840th of an inch diameter; and as the drop occupied a circle on a plate of glass containing 529 of these squares, the whole number of animalcules contained in the drop must have been about 26,450.

the helm, when the sea for a moment retired; and, without listening to all that was said regarding the supposed cause of the phenomenon, I ordered a bucket of water to be drawn up, and filtered into a basin through a fine linen handkerchief. After this operation, I observed that the filtered water was no longer luminous, but that the handkerchief was covered with many brilliant points. Some of these I raised on the end of my finger, and found that they had a certain consistence as animal bodies; being thus exposed, they gradually lost their brightness, and as they resembled the eggs or spawn of fishes, in form and dimensions, I at first yielded to the belief, which was pressed upon me, that they actually were so.

"Being anxious to examine one in a clear light, and placed under a strong magnifying glass, I was surprised to observe a sensible movement in its interior. Being doubtful of what I saw, I turned it in many directions, placing it on my nail in the centre of a drop of water. But what was my surprise, when I perceived it became surrounded by a brilliant fluid, perceptible to all those who were in the cabin, as well as to myself. On this I did not fail to pursue my observations, and having drawn up a greater quantity of water, I caused it to be filtered as before, and immersed the handkerchief, which had served for that purpose, into a basin of the pure sea water. I then instantly perceived a considerable number of small insects swimming about with celerity, which, at first sight, bore a resemblance to those commonly called in France *puces d'eau*, or water fleas. In spite of their agility, I succeeded in arresting one, by entangling it in a hair pencil, fixed against the sides of the goblet: this pressure, though slight, seemed too strong for so delicate a being, it suffered from it, and notwithstanding the light of two candles, by which we were pursuing our examination, we could perceive issuing from its body a luminous and bluish coloured liquid, of which the traces extended in the water to the distance of two or three lines. This accident did not induce me to leave my hold; I raised it up on the point of the pencil, and scarcely was it placed under the microscope, than it again shed forth a quantity of that cerulean liquid.

"I expected that so great an exertion would have weakened it extremely, but I had again the satisfaction to see it apparently full of life, and stirring about with vivacity.

"It was not in consequence of the examination of a single specimen that I ventured here to give its figure under a variety of aspects. The abundance with which I was then sur-

rounded, enabled me to sacrifice many, that I might be assured of all the parts of which they were composed; and I examined several which I found next day rather in a languishing state, but which a change of water reanimated. The brilliant liquid of which they have so ample a reservoir, was not even altered; for, having left, during some time, attached to the pencil, one of those which I had destined for examination by the microscope, it spread out a brightness which lasted seven or eight minutes, and was visible, even in full day, to various persons, at the distance of several feet."

Many of the most lively specimens of these animals having been put into fresh water, very clear, and freed from all disagreeable intermixture, they were immediately precipitated to the bottom, became strongly agitated or convulsed, and died in about six seconds. Many of them, while expiring, gave out a quantity of their bright phosphoric fluid.

It seemed absolutely necessary, in order that the insect might exert this power, that it should be in a state of humidity. When the moisture was absorbed, none shone even when bruised. Those which Godeheu had withdrawn from the sea, and placed in the same water in which he had found them, died one after another; but the water in which they had been preserved, shone with a very lively light. A phosphoric matter collected in consequence of this observation, did not, however, last for any time. Three days were sufficient to make it lose its luminous property.

This little animal appeared to be inclosed in, or protected by, a scaly covering or shell. Its general contour might be said to resemble an almond split down one side, and a little sloped at its superior part. The posterior extremity of its body presented many globules, in the form of a moveable group or cluster. These globules are of a bluish-green, which becomes of a tarnished yellow, in proportion as the animal approaches its end. Godeheu perceived in these grains, the phosphoric matter with which it is provided. We can scarcely doubt that these minute corpuscles are the eggs, and thence their luminous property is the less surprising, since the eggs of many fishes, and of several insects, present us with a similar phenomenon.

Its superior part is furnished with four moveable antennæ or horns, formed of many articulations, and terminated by tufts of very fine hair. The head is placed in the centre, and armed with some small hooks. Beneath it are two feet, bent, and furnished with hooks, and lower down there occur other organs of movement.

## Art. IX.—*Account of Mr Perkins's Improvement in the Art of Engraving.* [T.]

The voyage to England of this mechanic, two or three years since, occasioned considerable excitement amongst our citizens generally. And indeed it is not unlikely that the favourable construction which was put upon it, as evincing our superiority in the arts, had somewhat of an unfavourable influence on the minds of the Bank of England Commissioners. As many of our readers, however, may not have had an opportunity of obtaining any very precise knowledge of Mr Perkins's improvements, we have thought a short account of them may not be unacceptable. The change which this gentleman has in a degree introduced into the art of engraving, had its beginning in an attempt to render bank notes less easily counterfeited. He was aware that the most effectual way to prevent forgery, would be, to have the notes of different banks as nearly similar as possible, so that every body might become familiar with their appearance; and to put large quantities of engraving of the most difficult execution on every note. The legislature of this commonwealth, on the representations of Mr Perkins, passed a law favourable to the first of these conditions; and his substitution of steel for copper, as a material for plates, answered the second. The superiority of steel over copper is only in its durability. For, while it is well known that a few hundreds of impressions from a copper plate sensibly affect the beauty of an engraving; hundreds of thousands have been taken from a single steel plate without making any perceptible alteration in it.

The method of preparing the steel for the graver, and of hardening it after the design was completed, was after many experiments perfected by Mr Perkins. The last of these was peculiarly difficult; for, from the great disposition which heated steel has to oxidate it was necessary to keep it from the contact of air, and water. He succeeded so well, however, by adopting a mode somewhat similar to that practised in case-hardening, that the most delicate touches of the graver are not at all *scaled* or defaced by the process. As his manner of de-carbonating and re-carbonating the steel may be of great value in working that substance, for purposes unconnected with engraving, we shall extract from the specification of his English patent, his description of it.

"The Patentee makes use of good cast steel, in preference to any other sort of steel, for the purpose of making plates,

cylinders, circular, or other dies, and more especially when such plates, cylinders, or dies are intended to be de-carbonated.

"In order to de-carbonate the surfaces of cast steel plates, cylinders, or dies, by which they are rendered much softer, and fit for receiving either transferred or engraved designs, the patentee discovered that pure iron filings, divested of all foreign or extraneous matters, produce the softest de-carbonated surface; and therefore, he proposes the use of iron filings as pure and as free from rust as can be obtained, carefully excluding all carbonaceous matter, and any substance from which carbon can be obtained.

"The stratum of de-carbonated steel, should not be too thick for transferring fine and delicate engravings: for instance, not more than three times the depth of the engraving. The surface of the steel may be de-carbonated to any required thickness.

"To de-carbonate it to a proper thickness for fine engravings, it is to be exposed for four hours to a white heat, enclosed in a cast iron box, with a well closed lid. The sides of the cast iron box, are made at least three quarters of an inch in thickness, and at least a thickness of half an inch of pure iron filings, should cover or surround the cast steel surface to be de-carbonated. The box is to be suffered to cool very slowly, which may be effected, by shutting off all access of air to the furnace, and covering it with a layer, six or eight inches in thickness, of fine cinders. Each side of the steel plate, cylinder, or die, must be equally de-carbonated to prevent it from springing or warping in hardening. It is also found that the safest way to heat the plates, cylinders, or dies, is in a vertical position.

"For the reason given above, the steel is de-carbonated, solely for the purpose of rendering it sufficiently soft for receiving any impression intended to be made thereon. It is therefore necessary that, after any piece of steel has been de-carbonated, whether it be in the shape of an engraved plate, or a cylinder, or a die with engraved, or other figures upon its surface, in order to receive such figures, &c. it should be again carbonated, or re-converted into steel capable of being hardened. In order, therefore, to effect this carbonization or re-conversion into steel, the following process is employed: a suitable quantity of leather is to be converted into charcoal by the well known method of exposing it to a red heat, in an iron retort for a sufficient length of time, or

until all the evaporable matter is driven off from the leather. Having thus prepared the charcoal, it is reduced to a very fine powder; then, take a box made of cast iron of sufficient dimensions to receive the plate, cylinder, or die, which is to be reconverted into steel, so as that the intermediate space between the sides of the said box, and the plate, cylinder, or die, may be about one inch. This box is to be filled with the powdered charcoal, and having covered it with a well fitted lid, let it be placed in a furnace similar to those used for melting brass, when the heat must be gradually increased until the box is somewhat above a red heat; it must be suffered to remain in that state, until all the evaporable matter is driven off from the charcoal. Then remove the lid from the box, and immerse the plate, cylinder, or die in the powdered charcoal, taking care to place it as nearly in the middle as possible, so that it may be surrounded on all sides by a stratum of the powder of nearly an uniform thickness. The lid being replaced, the box with the plate, cylinder, or die, must remain in the degree of heat before described for from three to five hours, according to the thickness of the plate, cylinder, or die, so exposed. Three hours are sufficient for a plate of half an inch in thickness, and five hours when the steel is one inch and a half in thickness. After the plate, cylinder, or die, has been thus exposed to the fire for a sufficient length of time, take it out from the box, and immediately plunge it into cold water. It is important here to observe, that it is found by experience that the plates or other pieces of steel, when plunged into cold water, are least liable to be warped or bent, when they are held in a vertical position, or made to enter the water in the direction of their length. If a piece of steel, heated to a proper degree for hardening, be plunged into water and suffered to remain there until it becomes cold, it is found by experience to be very liable to crack or break, and in many cases it would be found to be too hard, for the operations it was intended to perform. If the steel cracks or breaks it is spoiled. In order to render it fit for use, (if by accident it becomes too hard,) should it happen not to be broken in the hardening, it is the common practice to heat the steel again, in order to reduce or lower its temper, as it is technically called. The degree of heat to which the steel is now exposed, determines the future degree of hardness, or the temper, and this is indicated by a change of colour upon the surface of the steel. During this heating, a succession of shades is produced from a very pale straw colour to a deep

blue. It is found, however, by long experience that, (on plunging the heated steel into cold water, and suffering it to remain there no longer than is sufficient for lowering the temperature of the steel to the same degree as that to which a hard piece of steel must have been raised, in order to temper it in the common way,) it not only produces the same degree of hardness in the steel, but what is of much more importance, almost entirely does away the risk or liability of its cracking or breaking. It is impossible to communicate by words, or to describe the criterion by which we can judge of, or determine, when the steel has arrived at the proper degree of temperature, after being plunged into cold water; it can only be learned by actual observation, as the workman must be guided entirely by the kind of hissing or singing noise, which the heated steel produces in the water, while cooling. From the moment of its being first plunged into the water a varying sound will be observed; and it is at a certain tone before the noise ceases, that the effect to be produced is known. The only directions which can be given, whereby the experimentalist can be benefitted, are as follows: namely, to take a piece of steel which has already been hardened by remaining in the water till cold, and by the common method of again heating it, to let it be brought to the colour which would indicate the desired temper of the steel plate to be hardened by the above process; as soon as he discovers the colour to be that of pale yellow, or straw colour, to dip the steel into water, and attend carefully to the hissing, or as some call it, singing noise, which it occasions; he will then be better able, and with fewer experiments, to judge of the precise time at which it should be taken out."

A method of reducing the temper, if it is found too high, is then described in the specification. But as this does not differ essentially from that in common practice we shall not extract it.

The next step of Mr Perkins in improvement, and that indeed which now constitutes the principal characteristic of his system, was a method of transferring an engraving from a steel plate to another plate either of steel or copper. The machinery for this is very simple, and consists merely of a cylinder of soft steel, the circumference of which is pressed with considerable force upon the face of a plate previously engraved and hardened. The cylinder is then rolled backwards and forwards over the plate, until the engraved lines are taken up in sharp relief; it is then hardened, and by applying it to a plane surface of soft steel or copper, in the same

way that it was before applied to the engraved one, it gives an exact impression of all the lines or characters which it received from the engraving.

This process furnishes the means of rendering an engraving eternal, and is capable of multiplying the original work of an artist, to almost as great a degree, as the art of printing can multiply the original work of an author. It is, in fact, a sort of printing on metal; and when it is considered that hundreds of plates may be impressed by one cylinder, and that each plate may be hardened and furnish impressions to hundreds of cylinders, there seems no end to the number of copies which may be obtained by means of one original engraving.

Of any design then of which a great number may be wanted, the plate may be executed in the very best manner, if this system be pursued, without enhancing the price of impressions, because the great number which may be taken from it fully compensates for the superior cost of engraving it.

In the application of this method to Bank notes, a difficulty is not only thrown in the way of counterfeiters, by the fine execution of the genuine plate, which can only be imitated by an equal artist, labouring an equal time; but the system of transfers furnishes the means of bringing together the works of *many* artists, each in his peculiar style, on the same plate. The security against counterfeit notes is, however, but a small part of the benefit which it is believed the public will derive from this invention. The number of engravings required for books, and the potteries, are of great amount, and the influence which Mr Perkins's system will have on their manufacture, must in a few years be extensively felt.

In the execution of his work, particularly some of the fine specimens which he has exhibited in England, great use has been made of a lathe, invented by Mr Spencer, formerly of New London, and which is one of the most beautiful pieces of mechanism which our country has produced.

We may mention that since Mr Perkins has been in England, a M. Guillot, ex-director of assignats, has claimed for some French artists the invention of a method of transferring engravings from one plate to another, as early as the year 1791. It appears, however, by his description of the process employed by them, that it was extremely rude, bearing no resemblance whatever to Mr Perkins's method, and that it was necessarily abandoned in its very infancy, as wholly useless.

**Art. X.—*Observations on the use of Cast Iron, with an Account of some late Experiments on its Strength.* [T.]**

The extensive use now made of cast iron, and that for purposes to which but a few years ago it was not thought of applying it, renders every investigation of its properties and the modes of manufacturing it important. This material, instead of being now confined it its use to a few culinary vessels and coarse implements, is not only used, to the exclusion of almost every thing else, for machinery, but houses, bridges, roads, and even vessels have been constructed of it. Circumstances in England no doubt favour this extensive use much more than they do in this country. Coal and iron ore are there abundant, and wood is scarce and dear; while in New England we have no good mineral coal, and our forests of timber are yet extensive.

The use of cast iron for machines, has, however, become very general in this country. Without it the inventions of the present age could never have been carried into effect. A machine constituted of wood, subject to constant swelling and shrinking and warping with every change of the atmosphere, is always liable to derangement. Indeed it can be said to be hardly capable of preserving its identity; while castings undergo no change of figure, and their trifling change of magnitude, by the variation of temperature, is a matter of small moment.

A great deal yet remains to be done to improve the quality of castings in this country, but the demand for them, such as they are, is yet too great for us to expect the furnace owners and masters to give much attention to experiments for this purpose. The perpendicular mode of casting is very far from common at the furnaces in this vicinity, although it undoubtedly possesses advantages which should lead to its universal adoption. The strength of a bar, as has been ascertained by experiment, cast perpendicularly, being to that of one cast horizontally as 1218 is to 1166, while it is much less liable to air bubbles and imperfections of that kind, which render abortive the skill and calculations of the machinist. This superiority is not, as might be supposed from the terms employed, the effect of mere position, but of the pressure of the upright column; and if this is increased by a weight of extraneous metal, the casting is still more likely to be sound. This principle has lately been carried to the extent of compressing the fluid casting by mechanical means.

Iron has usually been divided into three kinds, the white, grey, and black, but as these pass into each other in every degree, it often happens that some castings do not bear the character of any one of the above kinds more than another. The white iron is hard and brittle, and it does not seem to be well understood to what this is to be attributed; while the black is soft and tender, and bears all the marks of containing too great a quantity of carbon. The grey iron, or gun metal, as it is sometimes called, is superior for almost every purpose; it is sufficiently soft to yield to the file, and is much stronger than either of the other kinds.

Cast iron, when used in machines or for buildings, should never be subjected to a weight or pressure which will produce a permanent alteration of its figure, or a *set*, as it is called by the workmen. As this can only take place from a change of the relation which the ultimate particles have to each other, small additions to a force which is sufficient to produce this change, will be sufficient to increase it until the relation is destroyed altogether. Although this may be taken as a principle, yet there is some limit in its application, depending on the shape and size of the bar, the kind of iron, and the direction of the force. It seems true of some bodies, particularly those of a crystalline, or vitreous structure, that if strained, or if their particles are once separated beyond a certain point, the separation becomes complete. This point corresponds with that of their power to recover their former relations or distances; or the elastic power of the body. In these no permanent alteration of figure can be produced, for a fracture is the consequence of any force which destroys the elastic power. The hard kind of iron approaches this structure, and there is one considerable advantage in using it, which is, that it breaks immediately, if it break at all. Whereas, with the softer kinds, which will bear a permanent alteration of figure, the fracture may not take place until the force has continued to operate some time. But if a force be applied to this kind of iron, sufficient to produce such alteration, and be continued for a long time; or if the direction of it be constantly changing, as is often the case in machines, a fracture will at length be the result. Much, however, depends on the shape of the bar, and the direction of the force; where that direction is constant. As in a bar to which the force is applied transversely, if the iron be soft, the particles can undergo some change in distance beyond their elastic force, without loosing their cohesive attraction. In this case those that are situated in the middle of

the bar do not undergo any strain until the bar is somewhat curved; when an additional force is sustained by those particles as this curvature is produced, and before the particles situated outside are strained to the fracturing point. But in cases where the direction of the fracture must be at a right angle to the direction of the force, the principle, first stated, that the force applied should not be sufficient to produce a permanent change of figure, may be taken as true. This seems like going too much into the dark abyss of ultimate atoms; but as the facts above stated will be acknowledged, we hope to be excused for the manner in which we have connected them.

In forming castings to bear a transverse strain, it is common to increase the depth to equal several times the breadth; it having been generally understood that the strength is as the square of the depth multiplied into the breadth. But by the experiments of Mr Rennie, (Phil. Trans. part 1st, 1818,) this rule was not found to hold in a bar of the depth of 4 inches, and the breadth of ¼ of an inch, although it held nearly up to this proportion; and that gentleman thinks it evident that the system of deepening has been carried nearly to its limits.

Experiments on the absolute strength of cast iron have been made by several individuals, philosophers as well as engineers. Those of Mr Rennie, (Phil. Trans. 1818,) and some by Mr Tredgold, an account of which has lately been published, are deserving of considerable attention. Mr Rennie's experiments were made with an apparatus well calculated to give correct results. They show the power of iron to resist compression; its power to resist a twisting force; its tenacity when the force is applied to the bars in the direction of their axis, and when applied at right angles to that direction.

His experiments to find the power of iron in resisting compression, gave the following results. Cubes of ¼ of an inch, taken from the middle of a large block, were crushed with a weight of 1440 lb. And what may seem somewhat anomalous, in several trials on specimens having the same area as the preceding, but an increased height, the force required to crush them was increased. Cubes of ¼ of an inch were not crushed with a force less than 10,351 lb. on an average. As might be expected, the power of resistance is not as the area, but advances by a more rapid progression.

Mr Rennie relates but two experiments on cast iron to ascertain its power to sustain weight, when directly suspended

from the ends of bars. These were made with bars of $\frac{1}{16}$ of an inch area, and gave a mean of 1193 lb. equal to 19,088 lb. per inch. By the experiment of Muschenbroëk a bar of 1 inch area will sustain 63,286 lb. Mr Rennie found that bars of $\frac{1}{4}$ of an inch square, having one end fixed in a vice, and a lever three feet in length, applied in a proper manner to twist them, were capable of sustaining about 9 lb. on the end of the lever. His experiments on the strength of bars to resist a force applied transversely, gave the following results. A bar 1 inch square, with supports 2 feet 8 inches apart, broke under a weight of 1086 lb. With the supports 1 foot 4 inches apart, a bar of the same size broke under 2320 lb. A bar 2 inches deep, $\frac{1}{2}$ an inch thick, 2 feet 8 inches long, broke with 2185 lb.; and, with the supports 1 foot 4 inches apart, it was again broken with 4508 lb. Triangular prisms, a cross section of which contained the same area as the foregoing pieces, were fractured with 1437 lb. when one of the angles was placed uppermost, and with 840 lb. when the angle was down, the supports in both cases being 2 feet 8 inches distant. Bars 3 inches deep and $\frac{1}{3}$ of an inch thick, and 4 inches deep and $\frac{1}{4}$ of an inch thick, required weights of 3588 lb. and 3979 lb. respectively to fracture them, when the supports were 2 feet 8 inches apart. Such are some of the experiments of Mr Rennie. He also repeated the paradoxical experiment of Emerson, and found it true, that in triangular prisms, where the force is intended to act on one of the sides, the prism becomes stronger by having the portion containing its opposite angle cut away. That is, a part is stronger than the whole.

Mr Tredgold's work, of which we have before spoken, is of a less experimental character than might be desired. He has, however, noticed some of the experiments of Mr Rennie, and has given an account of others made by several different persons.

Mr Tredgold has calculated two tables, the first shewing the weight that bars of cast iron, of different magnitudes, will bear, without producing a deflexion or curvature of more than $\frac{1}{40}$ of an inch for each foot in length. This table was calculated from the equation $a\,W\,L^2 = B\,D^3$, in which W is the weight in pounds, L the length in feet, and B the breadth, and D the depth of the bar, in inches. The value of $a$ was found by the following mode of investigation. Mr Tredgold measured the deflexion of several loaded bars, and denoting it by $d$ inches, he took the proportion $d : W :: \frac{L}{40} : \frac{WL}{40\,d}$

and putting this for W in the former equation it becomes $\frac{a\,W\,L^3}{40\,d} = B\,D^3$ and $a = \frac{40\,B\,D^3\,d}{W\,L^3}$ and substituting the numbers furnished by an experiment we have $\frac{40 \times 1 \times 1 \times 1}{971 \times 27} = .00152$. He considers this too high a value and as other experiments furnished it lower, he uses .001*.

The second table in this work shows, by inspection, the weight which cast iron beams or bars of 1 inch in breadth, and of different lengths and depths, will bear without destroying the elastic force. These loads are set down at about one third of the load which would be required to produce immediate fracture, and the strength of equal lengths are founded on the rule of the square of the depth by the breadth.

Mr Tredgold has taken it for a truth, "that while the force is within the elastic power of the material, bodies resist extension and compression with equal forces." As this seems not only to require proof but to be in contradiction to many experiments, and as a great many of his calculations were founded on this as an axiom, we can have no confidence in the results of them.

We shall end this paper by a statement of the comparative power of a few different materials to sustain weights by suspension, according to Mr Rennie's experiments.

| | | | | lbs. |
|---|---|---|---|---|
| 1-4 inch cast iron bar, horizontal, sustained | | | | 1166 |
| 1-4 inch cast iron bar, vertical, | | | | 1218 |
| 1-4 inch cast steel previously tilted | | | | 8391 |
| 1-4 inch blister steel, reduced per hammer, | | | | 8322 |
| 1-4 inch shear steel | do. | do. | | 7977 |
| 1-4 inch Swedish iron | do. | do. | | 4504 |
| 1-4 inch English iron | do. | do. | | 3492 |
| 1-4 inch hard gun metal, | | | | 2273 |
| 1-4 inch wrought copper, | | | | 2112 |
| 1-4 inch cast copper, | | | | 1192 |
| 1-4 inch fine yellow brass, | | | | 1123 |
| 1-4 inch cast tin, | | | | 296 |
| 1-4 inch cast lead, | | | | 114 |

* Any of the results comprised in this table may be found by the practical man, by multiplying the cube of the depth of any bar in inches, by the breadth in inches, and dividing this product by the square of the length in feet. If this quotient be again multiplied by 1000, the product is equal to the number of pounds which the bar will sustain, without a deflexion of more than 1-40th of an inch to each foot, according to Mr Tredgold.

**Art. XI.**—*Some account of an assemblage of Fossil Teeth and Bones of the Elephant, Rhinoceros, Hippopotamus, Bear, Tiger, Hyena, and sixteen other animals; discovered in a Cave at Kirkdale, Yorkshire, in the year* 1821. By the Rev. William Buckland, F. R. S., F. L. S., V. P. of the Geological Society of London, Professor of Mineralogy and Geology in the University of Oxford. *Abridged from the Philosophical Transactions.* [J..W.]

In the summer of 1821, a discovery was made of a singular collection of bones in a cave at Kirkdale, in Yorkshire; the facts relating to which, as collected and stated by professor Buckland, seem calculated to throw an important light on the state of our planet at a period, antecedent to the last great convulsion that has affected its surface. Of these facts we propose to give some account, principally abstracted from the learned and interesting paper of the gentleman just mentioned, in the Philosophical Transactions for 1822*.

Kirkdale is situated about 25 miles N. N. E. from the city of York. The rock perforated by the cave is referable to that portion of the oolite formation which, in the south of England, is known by the name of the Oxford oolite and coral rag: its substance is interspersed with siliceous matter, forming irregular concretions, beds, and nodules of chert in the limestone, and sometimes entirely penetrating its coralline remains. The abundance of such caverns in the limestone of the vicinity of Kirkdale, is rendered probable by the engulphment of several rivers in the neighbourhood in their passage; and it is important to observe that the elevation of the Kirkdale cave, above the bed of the nearest river, exceeding 100 feet, excludes the possibility of attributing the muddy sediment it has been found to contain to any land flood, or extraordinary rise of the waters of that, or any other now remaining river.

The cave was discovered accidentally by a number of workmen, engaged in carrying on the operations of a large

* The word *diluvium* is applied in this article to those extensive and general deposits of superficial gravel, which appear to have been produced by the last great convulsion which has affected our planet, and which probably consisted in a pretty recent and transient inundation. The epithet *diluvial* is applied to the results of this great convulsion, *antediluvial* to the state of things immediately preceding it, and *post-diluvial* or *alluvial* to that which has succeeded it, and has continued to the present time.

quarry. Its mouth was closed externally with rubbish, the nature of which was not scientifically examined, and overgrown with grass and bushes. About 30 feet of the outer entrance of the cave have been removed, and the present entrance is a hole in the perpendicular face of the quarry, less than 5 feet square, which it is only possible for a man to enter on his hands and knees, and which expands and contracts itself irregularly from 2 to 7 feet in breadth and height, diminishing however as it proceeds into the interior of the hill. The greatest length is from 150 to 200 feet, its interior is divided into a number of smaller passages, the length of which has not been ascertained, and it is intersected by some vertical fissures. There are but two or three places where it is possible for a man to stand upright, and these are at the places of the fissures. These continue open but for the height of a few feet, when they gradually close and terminate in the body of the limestone; they are thickly lined with stalactite, and are attended by no fault or slip of either of their sides. Both the roof and floor for many yards from the entrance, are composed of horizontal strata of limestone, uninterrupted by the slightest appearance of fissure, fracture, or stony rubbish of any kind; but farther in, the roof and sides become irregularly arched, presenting a very rugged and grotesque appearance, and being studded with pendant and roundish masses of chert and stalactite; the bottom is visible only near the entrance, and its irregularities, though apparently not great, have been filled up throughout to a nearly level surface, by the introduction of a bed of mud or sediment.

This bed covers the bottom of the cavern to the average depth of about a foot. Its surface was found nearly smooth. Its substance is argillaceous and slightly micaceous loam, composed of such minute particles, as would easily be suspended in muddy water, and mixed with much calcareous matter, that seems to have been derived in part from the dripping of the roof, and in part from comminuted bones. It is covered in some places by a calcareous crust, formed by the water trickling down the sides of the cavern, and flowing over the surface of the mud. In this bed of mud were found the principal part of those animal remains, which form the most remarkable circumstance relating to the cavern. These remains consist entirely of bones; the mass of sediment contains no black earth, and no admixture of animal matter, except an infinity of extremely minute particles of undecomposed bone.

The layer of mud in which the bones are found imbedded, appears to have had a remarkable effect in preserving them from decomposition. Some that appeared to have lain a long time before its introduction, were in various stages of decay; but even in these its progress seems to have been arrested; and in the greater number, little or no destruction of their form, and scarcely any of their substance, has taken place. On immersing fragments of these bones in an acid, till the phosphate and carbonate of lime were removed, it has been found that nearly the whole of their original gelatine has been preserved. There are other instances of preservation from decay by means of a bed of mud, as distinct and remarkable as this, whilst bones in every other respect similar, which have laid a similar length of time in situations exposed to air and moisture, have lost their compactness and strength, their gelatinous portion has been destroyed, and they are often ready to fall to pieces on the slightest touch.

The bottom of the cave, upon removing the mud, was found to be strewed all over like a dog kennel, from one end to the other, with hundreds of teeth and bones, or rather broken and splintered fragments of bones belonging to a great number of animals. They were supposed by those who first visited the cavern, to be the bones of cattle that had died some years previous in great numbers, of a murrain, and many of them consequently were scattered and lost. A more scientific examination of them, however, has proved, that they belonged to the following twenty-two species of animals.

Carnivora, 7. Hyena, tiger, bear, wolf, fox, weasel, and an unknown animal of the size of a wolf.

Pachydermata, 4. Elephant, rhinoceros, hippopotamus, and horse.

Ruminantia, 4. Ox, and three species of deer.

Rodentia, 3. Rabbit, water-rat, and mouse.

Birds, 4. Raven, pigeon, lark, and a small species of duck.

Beside the bones, the cavern contained also the remains of horns of at least two species of deer. No horns were found entire, but fragments only, broken and ground to pieces like the bones, and the lower extremity in most cases, shewed by the rounded state of the base, that they had fallen off by absorption or necrosis and not been removed by violence.

A remarkable circumstance, with regard to all the bones found, was, that scarcely any of them had escaped fracture,

except the teeth and some of the small bones belonging to the carpus and tarsus. On some of them were to be detected marks, as if of the teeth of an animal, which had been gnawing them; and these marks have an exact correspondence, on comparison, with the teeth of the hyena. But the same marks were found upon the bones of the hyena, as well as upon those of other animals. Heaps of small splinters, and fragments, laid in different parts of the cavern, mixed up with the teeth and other bones, and sometimes connected together into a mass by the calcareous deposition. No skull was found entire, nor large pieces of bone enough of any one animal to form a skeleton. In the case of all the animals, the number of bones of the tarsus and carpus and of teeth, was more than twenty times as great as could have been supplied by the individuals, whose other bones were found mixed with them.

The greatest number of teeth are those of the hyena. Enough have been found to have belonged to seventy-five individuals. Next to the hyena are the ruminating animals. Of the others the number is smaller, except of the water-rat, the quantity of whose teeth and bones is immense. The species of most of the animals whose remains were discovered in this cavern, is different from those of any now known upon the globe. Thus the bear must have been the ursus spelæus, whose bones have been found in Germany; and which probably equalled in size a large horse. The ox, the elephant, the rhinoceros, the hippopotamus, &c. are also specifically different.

The inference to be drawn from these facts is, that the cavern in question has, at some former period, been the habitation or den of a succession of hyenas, who dragged thither and devoured their prey, consisting as well of the dead bodies of the larger animals, who died by violence, or the course of nature, and were brought by piecemeal, as of the smaller, whom they destroyed by their own efforts. The probability of this supposition is increased by a knowledge of the character, habits and mode of life of the modern hyenas. They are intermediate in these respects between the cat and the dog tribes, not feeding like the former, exclusively on living prey, but like the latter, being greedy also of putrid flesh, and bones, which induces them to follow armies, and dig up human bodies from their graves. They inhabit holes which they dig in the earth, and chasms of rocks; and are in the habit of dragging bodies to them, and

accumulating bones in great quantities around them. The strength of their jaws is very great. They are indeed remarkable among other beasts of prey, for the strength of their necks and jaws, which gives them a considerable advantage, both in carrying off their prey and in masticating bones. They keep by day close in their dens or other habitations, and prowl abroad by night, having eyes like those of the cat, adapted for seeing in the dark.

The fossil hyena must have been, according to Cuvier, nearly one third larger than the largest modern species, and its muzzle shorter and stronger. Its bones have been found in a number of different situations on the continent generally mixed with those of other animals, such as the bear, elephant, horse, rhinoceros, &c. and in some of these cases in dens, like that at Kirkdale. The species described by Cuvier corresponds exactly with that discovered in the Kirkdale cavern.

It might be made a question, whether the fact that the hyena bones themselves are broken and gnawed, as well as those of the other animals, is not some objection to this account of the matter. Whether it is the habit of the modern animal to prey upon the bodies of its deceased companions is not certainly known. It is probable however that it is, and hence we may infer that the carcases, even of the hyena's themselves, were eaten up by their survivors.

This conjecture is rendered almost certain, by the discovery which has been made of the solid calcareous excrement of an animal that had fed on bones. Its external form is that of a sphere, irregularly compressed, as in the feces of sheep, varying from half an inch to an inch in diameter. It was at first sight recognized by the keeper of the Menagerie at Exeter Change, as resembling both in form and appearance, the feces of the spotted or cape hyena, which he stated to be greedy of bones, beyond all other beasts under his care. An analysis of this substance, by Dr Wollaston, gives such ingredients as might be expected in fecal matter derived from bones, viz. phosphate of lime, carbonate of lime, and a very small proportion of the triple phosphate of ammonia and magnesia; it retains no animal matter, and, its original earthy nature and affinity to bone, will account for its perfect state of preservation.

A large proportion of the teeth of the hyena bear marks of extreme old age, being worn down to the very socket; this also affords some confirmation of the supposition that

they had been employed in masticating bones. There are many teeth, however, of very young animals, and in one fragment of a jaw, the second set of teeth have not protruded, but were forming within the jaw, at the time of death. But besides this difference in age, there are other appearances in the bones of all the animals, which seem to have arisen from the different length of time they had laid exposed in the bottom of the den, before the muddy sediment entered, which, since its introduction, has preserved them from further decomposition. Some portions of bone are so much decomposed, as to be ready to fall to pieces by the slightest touch, these had probably lain a long time unprotected in the bottom of the den; others still older have probably entirely perished: but the majority of both teeth and bones are in a high state of preservation; and many thousands have been collected, and carried away, since the cavern has been opened.

In many of the best preserved bones, it has been observed that there is a partial polish and wearing away to a considerable depth on one side only; many straight fragments of the larger bones have one entire side, or the fractured edges of one side rubbed down and worn completely smooth, whilst the opposite side and ends are sharp and untouched; in the same manner as the upper portions of paving stones in the street become rounded and polished, whilst the lower parts retain their original form. This may be attributed to the friction produced upon the bones from the continual treading of the hyenas, and rubbing of their skin on the side that lay uppermost in the bottom of the den. A similar effect has been observed to have taken place upon a stone, in the den of a tiger, on which the animal was accustomed to repose.

All these circumstances render probable the conjecture just stated, that this cave was at some former period the residence of several generations of hyenas; that this period preceded the last general and important convulsion, to which our globe has been subjected, and which changed the surface of the earth, and destroyed many species of animals that previously existed. But although probability is in favour of this hypothesis, yet others may be suggested of various degrees of plausibility.

1. It may be said that animals had entered this cavern voluntarily, to die, or had fled to it for refuge from the great convulsion which destroyed them. But the diameter of the cave, would render this impossible with regard to the larger

animals; and with respect to the smaller, we can imagine no circumstances that would collect together those of such dissimilar habits. Neither does this supposition account at all for the state in which the bones are found.

2. It may be supposed that they were drifted in by the waters of the flood. But there is a similar objection to this as to the other opinion, the large animals could not enter, and beside the number, of those to whom these bones belonged, must have been far greater than the cavern could have contained, if they were carried in entire; and if the bones only were thrown in by the action of the water, then they would have been mixed with gravel, and at least slightly worn by the rolling motion to which they had been subjected.

Neither of these explanations are so satisfactory as that which was first stated. And it is to be inferred from the facts connected with this discovery, that that part of the earth where the cavern is situated, was at the time of the deposition of bones, inhabited by races of animals, which have never been known to exist in the same part of the world within the memory of man. The elephant, the rhinoceros, the hippopotamus, and the hyena, are now found only in Asia and Africa, and in fact the same species as those discovered in the cave at Kirkdale, are now entirely extinct. Cuvier has ascertained that the fossil remains of these animals belong to species now unknown, and they are only found in formations which must have been produced by the great deluge. It may be hence inferred that in the tremendous convulsions, which at that time entirely changed the surface of the earth, many species of animals were destroyed, whose existence can now only be ascertained from the remains which are occasionally detected. Had bones, such as those at Kirkdale, been found only in superficial gravel beds of diluvian origin, it might be supposed indeed that they were those of animals which had been floated from some other country by the waters of the flood, but the place and circumstances of the case incontestably show, that they were the native antediluvian inhabitants of the district where they were found, and had been for a succession of generations. A fact which is the more remarkable, since not only the species have become extinct, but even animals of the same genera and habits of life, do not reside in the same quarter of the globe, and have not, within the memory of the human race. It is still further worthy of notice that the bones of those animals, are also found widely diffused over the temperate, and even

polar regions of the northern hemisphere, whilst the living species of the same genera at present exist only in tropical climates, and chiefly south of the equator. The only country in which the elephant, rhinoceros, hippopotamus, and hyena are now associated, is southern Africa; in the immediate neighbourhood of the Cape, they all live and die together, as they formerly did in Britain; whilst the hippopotamus is now confined exclusively to Africa, and the elephant, rhinoceros, and hyena are also widely diffused over the continent of Asia.

Professor Buckland is of opinion that the history of the operations which have been going on in the cave at Kirkdale, may be comprised under four periods.

The first period preceded the time during which it was inhabited by the hyenas, and the existence of this period, a short one, is shown by a small quantity of stalagmite deposited upon the actual floor of the cave.

The second period was that in which it was the actual habitation of the hyenas, and during this time the bones were all deposited, whilst at the same time the formation of stalactite and stalagmite was going on. In evidence of this it is found, that many of the bones, now buried beneath the mud, are covered by stalagmite, and often several bones connected together by it; and since the stalagmitic depositions do not now, and could not, since the existence of the layer of mud, penetrate that layer so as to produce the effect spoken of, it follows that it must have been produced prior to its existence.

The third period was that in which the mud was introduced, and the animals extirpated, viz the period of the deluge. This mud seems to have been introduced in a fluid state, so as completely to envelope the bony fragments laying at the bottom of the cave. Such depositions have been frequently observed to follow land floods at the present day. There are no marks, however, which indicate that the layer of mud, in the cave at Kirkdale, could have been produced by a succession of such floods. It appears to have been introduced all at once, and that by the turbid waters of the great inundation. The cave is in itself remarkably dry, its situation precludes the possibility of any flood in the ordinary course of nature, and even in the most rainy seasons it is scarcely penetrated by a drop of water.

The fourth period was that which has succeeded to the deposition of the muddy sediment; during this period the cave

has remained wholly undisturbed, and nothing has been going on but the formation of stalactite on the sides of the cavern, and upon the surface of the mud. Probably, no living thing, except perhaps some of the smaller animals, mice, weasels, rabbits, and foxes, have entered the cavern since the great deluge, till the opening of it by workmen in 1821. To judge from the quantity of stalactite, formed during this last period, it has not been one of excessive length.

Other discoveries of bones, similar in character to these found at Kirkdale, had been previously made in Great Brittain, but under circumstances which did not so clearly indicate their origin and history.

At Nicholaston, on the coast of Glamorganshire, in the year 1792, a number of bones were discovered in a quarry of limestone, belonging to the elephant, rhinoceros, hyena, ox, and stag. They were found in a cavity in the rock, which was accidently intersected like the cave at Kirkdale.

Near the summit of the Mendip hills, near the village of Hulton, in sinking some ochre pits, several pretty extensive cavities were encountered formed in limestone, lined with ochreous clay, in which were found a considerable number of bones belonging to the elephant, hog, hare, ox, stag, and fox.

At Clifton, in a cavity of mountain limestone, have also been found several fragments of fossil bone, among which is a curious instance of a fossil joint of a bone.

Some bones and teeth of the elephant were also found in a similar cavity in Derbyshire, in 1663, in the course of working a lead mine.

Another example of the discovery of bones, which are probably of antediluvian origin, is related by Sir Everard Home, in the Philosophical Transactions, for 1807. They were discovered like the others, in cavities existing in limestone and filled with solid clay, in which the bones and teeth were imbedded. They belonged to the rhinoceros, deer, and a species of bear.

It is not probable that the bones were introduced in all these cases in the same way; by means of beasts of prey. For as these animals were the antediluvian inhabitants of the countries in which the caves occur, it is possible that some may have retired into them to die, others have fallen into the fissures by accident, and there perished, and others have been washed in by the diluvial waters.

Many caverns have been discovered on the continent containing bones of extinct species of animals, in greater or less

abundance, but they differ from the cave at Kirkdale in having their mouths open, so as to have been inhabited also by post-diluvial races of animals. Thus the celebrated cavern at Gailenreuth gives no indication that its mouth has ever been closed, yet it contains the bones of the great extinct species of bear (ursus spelæus) and the hyena, of the same species with that found in Yorkshire, and would, probably, have been tenanted at this time by wild beasts, had not the progress of human population extirpated them from Germany.

The remains of the elephant and rhinoceros are not found in the same cavern with those of the bear; whilst those of wolves, foxes, horses, mules, oxen, sheep, stags, roebucks, badgers, dogs, and men are; but the number of these is in very small proportion to that of the bears. The bones of all kinds occur in scattered fragments, and it is exceedingly difficult to procure a complete skeleton. They are also in very different states of preservation. Those of the bear and hyena, which are extinct species, being much more decayed than those of the other animals, which are of species yet existing. Whence is derived confirmation of the opinion that the remains of the former were introduced during the antediluvian, and those of the latter during the post-diluvian state of the earth. In corroboration also it may be stated, that skulls and bones of the ursus spelæus have been found in consolidated beds of diluvian gravel, forming a pudding stone, and those of the hyena in the diluvian gravel of France and Germany.

In these caverns the bones are generally disposed in the same way; sometimes scattered separately and sometimes accumulated in beds and heaps of many feet in thickness; they are found every where from the entrance to the inmost recesses; never in entire skeletons, but single bones mixed confusedly from all parts of the body, and animals of all ages. The skulls are generally in the lowest part of the beds of bone, having from their form and weight sunk or rolled downwards, as the longer and lighter bones were moved and disturbed continually by the living animals passing over them; the lower jaws are rarely found in contact with, or near to the upper ones, as would follow from the fact last mentioned. They are often buried in a brown argillaceous or marly earth, which seems to contain a large proportion of animal matter derived from the decay of the fleshy parts of the bears.

The bones are frequently encrusted and invested with stalactite, so as sometimes to connect entire beds and heaps of them together into a compact mass. They are, it seems most probable, the remains of animals which lived and died through successive generations, in the caves where they are now found, and which were also born there, since bones have been noticed which belonged to an individual that must have died immediately after birth, and to others which must have died young.

These caverns occur in Brunswick, in Hanover, in Franconia, at Gluckstrum in Westphalia, and Cuvier states that the bones found in them are identical over an extent of more than two hundred leagues; that three fourths of the whole belonged to two species of bear, both extinct; the ursus spelæus and ursus arctoideus, and two thirds of the remainder to extinct hyenas. A very few to a species of the cat family, being neither a lion, tiger, panther, or leopard, but most resembling the jaguar, or spotted panther of South America. There is also a wolf or dog, not distinguishable from a recent species, a fox, and polecat. He adds that, in the caves thus occupied, there occur no remains of the elephant, rhinoceros, horse, ox, tapir, or any of the ruminantia or rodentia. In this respect they differ materially from that of Yorkshire; but such variations are consistent with the different habits of bears and hyenas, arising from the different structure of their teeth and general organization; from which it follows that bears prefer vegetable food to that of animals, and, when driven to the latter, prefer sucking the blood to eating the flesh, whilst hyenas are, beyond all other beasts, addicted to gnawing bones.

But although the bones of other animals, than the bear and hyena, are extremely rare in the caves of Germany, yet those of the elephant and rhinoceros have been sometimes found in the caves themselves, and in their neighbourhood; which indicates that they were the antediluvian contemporaries of the bear and hyena, whose remains exist in the greatest abundance.

With respect to the sediment, or layer of mud, found covering the floor of the cavern at Kirkdale, it is hopeless to determine whether the German caves resemble it in this particular, as they have been opened and ransacked for centuries, and no note was taken of their original appearance. In some however of more late discovery, there was found a sediment of mud, and similar stalagmitic depositions, with the differ-

-ence that the earthy substance, of which the layer of mud was composed, contained a proportion of black animal earth which is absent in the Kirkdale cave, for a reason which has been already assigned.

These circumstances point, all of them, at an identity of time and circumstances between the English and German caverns, but this identity is not however, after all, so much to be inferred from a comparison between the stalactitic matter and earthy sediments which they contain, as on the agreement in species of the animals entombed in them, viz in the agreement of the animals of the English caves, with those of the diluvian gravel of the greater part of Europe; and in the case of the German caves, on the identity of the extinct bear with that of the diluvian gravel of Upper Austria; and the extinct hyena with that of the gravel of Canstadt, in the valley of the Necker, and at Eichstadt, in Bavaria; to these may be added the extinct rhinoceros, elephant, and hippopotamus, which are common to gravel beds as well as caves. And hence it follows, that the period, at which all these caverns were inhabited by the animals in question, was antecedent to the formation of that deposit of gravel, which it seems impossible to ascribe to any other origin than a transient deluge, affecting universally, simultaneously, and at no very distant period, the entire surface of our planet.

After the paper of professor Buckland had been read to the Royal Society, but before its publication, the discovery of another cave was made, containing chambers lined with stalactite, and having on its bottom, mud, and bones imbedded in the mud, in a quarry close to the town of Kirby Moorside. Another cavity, containing bones, was discovered about twenty years before in the same neighbourhood, but no record was preserved of it. Of the examination of the newly discovered cavern, no account has yet been published.

Professor Buckland also announces the reception of the lower jaw of an hyena, found in the same diluvian clay and gravel with the bones of the elephant and rhinoceros, being the first instance of the remains of the hyena being noticed in the diluvium of England. The animal must have perished, he thinks, by the same catastrophe which extirpated the hyenas, and closed the den at Kirkdale, and which swept together the remains of elephant, rhinoceros, and hyena in the diluvian gravel of the continent.

It may be mentioned, as connected with the subject of this article, that in a late number of the Journal of the Royal

Institution, is noticed the discovery of the bones of the rhinoceros by some miners engaged in search of lead ore, ninety feet below the surface of the earth, in the neighbourhood of Wirksworth, Derbyshire. The bones being in a high state of preservation, and the enamel of the teeth uninjured.

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ART. XII.—*An Account of some results obtained by the combined action of Heat, and Compression, upon certain Fluids; such as water, alcohol, sulphuric ether, and the rectified oil of petroleum.* By M. LE BARON CAGNIARD DE LA TOUR. [*Annales de Chimie et de Physique.*]

IT is well known that by means of a Papin's digester, the temperature of fluids may be raised much above their usual boiling point; and we are led to suppose that the internal pressure, which increases with the temperature, would be an obstacle to the total evaporation of the fluid, especially if the space left above the fluid be not considerable.

In reflecting on this subject, it occurred to me that the expansion of a volatile fluid had necessarily some limit, beyond which the liquid, notwithstanding the pressure, must be converted into vapour, little as the capacity of the apparatus allows the fluid to extend beyond its maximum of dilatation.

In order to verify this opinion, I put some alcohol of specific gravity 0.837, and a ball or sphere of quartz, into a small Papin's digester made of the end of a very thick gun barrel; the fluid occupied nearly one half of the apparatus. Having noticed the kind of noise which the ball occasioned while rolling in the cold gun barrel, and afterwards when it was slightly heated, I arrived at a point in which the ball seemed to rebound at each percussion as if it was no longer surrounded by a fluid in the gun barrel. This effect was best observed by applying the ear to the end of the handle, which served to support the machine; it ceased upon cooling, and was reproduced when the necessary degree of heat was again applied.

The same experiment was repeated with water, but with imperfect success; for on account of the high temperature which it was necessary to employ, the apparatus could not be perfectly closed. With sulphuric ether, and oil of petro-

leum, the case was different; they presented the same phenomena as alcohol.

In order to observe these effects of heat, and compression, with greater facility, I put the same liquids into glass tubes, closed at one end, and afterwards at the other, by means of the blow-pipe. A small piece of glass was fastened to each tube to serve as a handle.

One of the tubes, into which alcohol was introduced, so as to occupy nearly two fifths of it, was heated with the precautions requisite to prevent its being broken. In proportion as the fluid expanded, its mobility became greater; the fluid, after having attained nearly double its original volume, disappeared completely, and was converted into so transparent a vapour that the tube seemed suddenly empty; but on suffering it to cool for a moment, a very thick cloud was formed, after which the fluid re-appeared in its original state. A second tube, nearly half full of the same fluid, gave a similar result; but a third, of which the fluid occupied more than half, was broken.

Similar experiments, with oil of petroleum, and ether, presented nearly analagous results.

All the tubes were exhausted of air before they were closed, but the same results were obtained, when the experiments were repeated, with tubes from which the air had *not* been exhausted.

The last experiment was made with a glass tube, about one third full of water: the tube lost its transparency, and broke. It appears, that at a high temperature, water is capable of decomposing glass, by combining with its alkali: this suggests the idea, that some other result, interesting to chemistry, may perhaps be obtained, by increasing the application of this process of decomposition.

Careful observation of the tubes in which the air had been left, showed that those in which the fluid had not quite space enough to acquire the dilatation, preceding its conversion to vapour, did not always break, immediately after the fluid appeared to have completely filled this space.

May it not be concluded that fluids which are usually but slightly compressible at a low temperature, become more so at a high temperature? and still more strongly in the present case, in which the liquid is ready to become an elastic fluid under a pressure, which according to theoretical calculations, would appear to be equal to several hundred atmospheres?

With respect to this, there will probably be some difficulty in admitting, that a small glass tube scarcely three millimetres in diameter, and scarcely one millimetre* thick, should resist so considerable an expansive force ; it will perhaps, be thought preferable to suppose that the molecules of an elastic fluid, and particularly of a fluid vapour, are susceptible, at a certain degree of compression and heat, of assuming a change of state similar to semifusion, and capable of facilitating a greater reduction of volume than that derived from the absolute pressure. Until these doubts are removed by new experiments, it appears that we may recapitulate what has been stated, in the following conclusions.

1. That alcohol of specific gravity 0.817, oil of petroleum of specific gravity 0.807 and sulphuric ether, submitted to the action of heat and compression, are susceptible of being completely reduced to vapour under a volume rather exceeding twice that of each fluid.

2. That an increase of pressure, occasioned by the presence of air in several of the experiments which have been described, occasioned no obstacle to the evaporation of the fluid in the same space, that it merely rendered its expansion more quiet and more easy of observation until the moment in which the fluid suddenly disappeared.

3. That water, although undoubtedly susceptible of being reduced to very compressed vapour, could not be subjected to complete experiments for want of sufficient means to close the compressing instrument perfectly, as well as that it alters the transparency of glass tubes by combining with the alkali which enters into their composition.

I have presumed that this notice would be particularly interesting to those who are concerned in the use of steam engines, and also, probably, furnish some slight indications for the solution of the question relating to the compressibility of fluids, lately proposed as a prize subject by the Institute.

In a supplement to this paper an attempt has been made to determine the pressure which the ether or alcohol exert, at the moment when they are suddenly reduced to vapour, from which it appears that the ether exerts a pressure of 37 or 38 atmospheres; the alcohol 119 atmospheres. The former required a temperature of 160° Reaumur; alcohol 207° Reaumur.

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* The millimetre is equal to .03937 English inches.

# Scientific Intelligence.

*New Steam Engine.*—Most of the late journals from England contain accounts of a newly invented steam engine, founded, it is said, on the discovery of some property of steam which has hitherto escaped observation. The advantage which it is expected to possess in saving fuel has been variously stated, the lowest account states it at seven eighths; and it is said that it may be applied to propelling vessels with such effect, that it will be practicable to make a voyage to Calcutta, by means of it, in thirty days. Highly as we respect the genius of Mr Perkins, the inventor of this new engine, we cannot but doubt whether, after all the severe and exact experiments which have been made on steam, any property, capable of furnishing such prodigious results as are above stated, has escaped notice up to this late period. Perhaps, indeed, the scrutiny of Mr Perkins, may have brought to light some law, to which the known properties of steam conform, and on a knowledge of which improvements may be introduced into the engine. The specification of the patent for this invention will probably be published in July, and we shall then be able to get at the *substance* of the invention, which we ardently hope may equal the high expectation of the public.—[D. T.]

*New form of Voltaic Apparatus.*—Mr Pepys has constructed a single coil of copper and zinc plate, consisting of two sheets of the metals, each fifty feet long by two broad, having therefore a surface of 200 square feet: they are wound round a wooden centre, and kept apart by pieces of hair line interposed at intervals between the plates. This voltaic coil is suspended by a rope, and counterpoise, over a tub of dilute acid, into which it is plunged when used. When the poles are connected by a copper wire an eighth of an inch in diameter and eight inches long, it becomes hot, and is rendered most powerfully magnetic, and the instrument is admirably adapted for all electro-magnetic experiments. It is proposed to term this apparatus a Magnetomotor.—[*Jour. Roy. Institut.*]

*Velocity of Sound.*—On the 20th of February, a paper on the velocity and force of sound, was read before the Royal Society. It contains the observations and experiments of

John Goldingham, Esq. F. R. S. made at Madras. Mr G. gave the results of numerous observations, and they show that the velocity of sound is considerably affected by the different states of the atmosphere, and of the weather, and by the wind, contrary to what has been asserted. The last table showed the mean velocity at Madras for each month; the velocity increases to a maximum at the middle of the year, being then 1164 feet per second; the minimum is 1099 feet.

The mean rate at which sound travels, as assigned by Newton and Halley, is in almost precise accordance with the results of these experiments.

*Reduction of Sulphate of Lead.*—A paper of M. Berthier, published in the twentieth volume of the Annales de Chimie et de Physique, contains some facts which are of importance to dyers and calico printers. In obtaining the mordaunt, by the decomposition of alum by acetate of lead, a large proportion of sulphate of lead is at the same time procured. The experiments of M. Berthier prove that this sulphate may be reduced to metallic lead; which is effected by adding about one tenth of its weight of charcoal, and exposing the mixture to heat, by which a subsulphuret of lead is formed. This may be treated as galena, and the lead easily extracted.

A simpler method is to cause the sulphate and the sulphuret of lead to decompose each other. By mixing sulphate of lead with subsulphuret, and exposing them to a white heat in an earthen retort, pure sulphurous acid is evolved, and pure metallic lead is obtained, the loss being but about 5 per cent.

The conversion of sulphate of lead into oxide is effected by heating it to whiteness with .03 its weight of charcoal. The oxide is compact, vitreous, transparent, and of a fine resin-yellow colour.

In the reverberatory lead furnace, sulphate of lead and galena, in the proportion of 100 of the former to 79 of the latter, may be readily reduced together.

Sulphate of lead may be decomposed by the carbonate of either ammonia or potassa, the result will be *white lead*, but it is doubted whether the product would be equally fit for the painter's use with that obtained in the usual way.

*Primitive Boulders.*—"Throughout the whole of Finland, the evident traces of diluvian action are on the most astonishing scale. Without dwelling on the stupendous size and universal distribution of primitive boulders, it is impossible not to perceive, that the top of every rock *in situ*, every tor,

every hill and knoll of granite, or primitive rock, from its first appearance in Carelia, till it sinks beneath the Gulf of Bothnia, presents a surface as much rounded, and as visibly water-worn, as the boulders or colossal pebbles that lie round their bases. Where the rock *in situ* does not rise high above the soil, and where the boulders are at the same time thickly scattered, and of vast size, it is scarcely possible to distinguish one from the other. This is particularly the case between Wyborg and Fredericshamn, where they totally prevent the culture of the earth, and barely allow the passage of a carriage over a most tortuous and narrow road.—Another fact connected with this subject, and well worthy of remark, is, that in the south of Finland, where we recognise *in situ* the parent rocks of the commonest boulders of the neighbourhood of Petersburg, we find new varieties occurring in rolled masses, probably brought from rocks existing still further north. This circumstance much increases the interest attached to the primitive rocks in the north of Europe; since from this cause every rolled stone merits a certain degree of attention."—[*Trans. Geol. Soc. Lond.*]

The evidences of diluvian action in the vicinity of Boston and Salem are remarkably similar to those described above. At Roxbury and Dorchester the conglomerate is in many places covered, and in others skirted by accumulated boulders, derived however from the rock itself. Some of the masses are of vast size, and now rest upon the bare and rounded surface of the subjacent bed in such positions, as (in connection with the deep scratches and furrows on the surface of the bed, which uniformly have a direction towards the ocean) lead to the inference that these rolled masses have been brought into their present situation by the force of some current from the west.

Among these there is a very fine example of a rocking stone, not inferior to those of Cornwall, which have been so well described by Dr Mac Culloch, in the Transactions of the Geological Society, Vol. II.

The moveable rock at Roxbury measures 19 feet in length, its height is 7 feet, and its thickness about 5. It rests upon two projecting and cylindrical points, and two persons can with ease cause its upper edge, or apex, to describe an arc whose chord is 12 inches, at 7 feet distance from the centre of motion. Its form is irregular, but may be considered as a portion of a cylinder, terminated at each extremity by a pyramid. From these data, taking its specific

gravity at 2.5, we have calculated the weight of the mass to amount to 29 tons. It lies in a direction nearly east and west.—[J. W. W.]

*New Method of Tanning, Dyeing, &c.*—Mr J. Neilson has lately taken out a patent in England for some important improvements in the processes of tanning, leather dressing and dyeing. The leather is prepared in the usual way, and submitted to the action of an aqueous infusion of the following plants; namely,

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|---|---|
| Saxifraga, or Saxifrage, | Crassifolia. |
| —— —— | Cordifolia. |
| —— —— | Orbicularis. |
| Rheum, or Rhubarb, | Sibiricum. |
| —— —— | Crispum. |
| —— —— | Tartaricum. |
| Geranium, or Geranum, | Macrorhizum. |
| —— —— | Reflexum. |
| —— —— | Lividum. |
| —— —— | Phœum. |
| —— —— | Angelatum. |
| Heuchera, | Americana. |
| —— | Villosa. |
| Polygonum, | Undulatum, or |
| —— | Canadensi. |
| Rhodiola, | Rosea. |

These substances are used either green or dry; if green, the application of a moderate heat, by means of steam or warm water, is necessary. Whether used in the green or dry state they should be cut, bruised, or ground. The strength of these plants in making the new leather, compared with English oak bark, is as follows:

To make a pound of new leather, take double the weight of the green leaves of the saxifrages, that would be required of English oak bark, to make a pound of common leather. The root of the saxifrages, is double the strength of the leaves.

The rheum sibiricum and tartaricum are equal to the root of the saxifrages, but the crispum is rather weaker.

The geraniums and polygonums are about the same in strength as the saxifrage leaves, and the rhodiola rosea is nearly double in strength to the root of the saxifrages. The observations regard the weight of the plants as taken from the ground; when dried, they lose in weight about two

thirds, and they lose also a little in strength. The plants ought to be cropped when vegetation in them is stopped.

In the second place, and separately in the art of dyeing, as at present practised, a liquor is made from an infusion of nutgalls, or oak bark, with water, which is used as a basis mordaunt preparative, or constituent in dyeing. He has discovered that a new liquor, useful in dyeing, may be made by infusing the plants or herbs in the foregoing list, in water, by the same mode of manipulation as that by which the common liquors above mentioned are made. This new liquor may be applied to all the uses, and in the same manner to and by which the liquors made from sumach, nutgalls, or oak bark, are now generally applied by dyers as basis mordaunts, or preparatives as aforesaid.

*New Method of Glazing Earthen-ware.*—The large gold medal of the Society for the Encouragement of Arts, Manufactures, and Commerce, has been voted to J. Meigh, Esq. of Shelton, Staffordshire, for the discovery of a glaze for vessels of common red earthen-ware.

This glaze is fusible, cheap, and perfectly wholesome, liable to none of the objections to which the common lead, or litharge glaze is.

The ware, after being well dried, is immersed in a mixture of marl and water, by which the superficial pores of the clay are filled. Being carefully wiped the ware is ready for the glaze, which is thus composed.

Take 1 part Cornish granite,* consisting chiefly of felspar,
1 part glass,
1 part black manganese.

The whole well ground together and diffused in water to the consistence of cream, the ware is to be dipped in this mixture, and then baked in the usual way.

If an opake white glaze is required, the manganese is omitted.

*Method of Hardening Gypsum.*—By a letter from James Vine, Esq. to the Geological Society of London, it appears that if gypseous alabaster be heated considerably and then immersed in water, it acquires a degree of hardness so great as to admit of a polish like marble, and may be used for making slabs, and for other economical purposes.

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* Probably disintegrated granite, of which we have abundance in this country.—[*Ed. B. J.*]

*Soldering with Cast Iron.*—Sheet iron may be soldered by means of filings of soft cast iron, applied with borax deprived of its water of crystallization, and sal ammoniac. Tubes of sheet iron have been constructed at Birmingham lately by means of a process of this kind, which, according to Mr Perkins and Mr Gill, is to be practised in the following manner. The borax is to be dried in a crucible, not till it fuses, but till it forms a white crust; then powdered and mixed with the iron filings; the joint is to be made bright, and moistened with a solution of the sal ammoniac; then the mixture is to be made into a thick paste with water, and placed along the inside of the joint, and the whole heated over a clear fire till the cast iron fuses. —[*Tech. Rep.*]

*English Opium.*—Messrs Cowley and Staines, of Winslow, Bucks, have cultivated poppies for opium, with such success as to induce the belief that this branch of agriculture is of national importance, and worthy of support. In the year 1821, they procured 60 lbs. of solid opium, equal to the best Turkey opium, from rather less than four acres and a half of ground. The seed was sown in February, came up in March, and after proper hoeing, setting out, &c. the opium gathering commenced at the latter end of July. The criterion for gathering the opium was, when the poppies, having lost their petals, were covered with a bluish-white bloom. They are then scarified, and the head left until the juice is coagulated, (about two hours,) when it is removed, and fresh incisions are made. Opium is produced until the third or fourth incisions, and in some instances even to the tenth. Ninety-seven pounds one ounce were procured at an expense of £31. 11s. 2½d.; and this after due evaporation in the sun produced above 60 lbs. of properly dried opium. The heads were allowed to dry, and were then gathered and thrashed; the seed separated by coarse riddles, and cleaned by fine sieves and a fan, amounted to 13 cwt. and was expected to produce 71¼ gallons of oil. The oil cake was given to pigs and cattle, with great advantage.

From the capsules, an extract was obtained by cold infusion, eight grains of which are equal to one of opium; an acre produces 80 lbs. of it. The straw forms an excellent manure.

The quantity of opium consumed in great Britain annually is estimated at 50,000 lbs. exclusive of exportation.—[*Trans. Soc. Arts.*]

*Rafflesia Titan.*—This wonder of the vegetable kingdom is a native of the forests in the interior of Sumatra. An account of it, with splendid coloured figures, has lately been published by Mr Brown, in the Linnean Transactions. It is named in honour of Sir Thomas Stamford Raffles. This gigantic flower is parasitic on the lower stems and roots of the *cissus angustifolia*, Roxb. The bud, before expansion, is nearly a foot in diameter, and of a deep dusky red. The flower, when fully expanded, measures across from the tip of one petal to the tip of the other, little short of three feet. The cup is estimated to be capable of containing twelve pints; and the weight of the whole is from twelve to fifteen pounds. The inside is of a deep purple, but towards the mouth, it is marked with numerous spots of white. The petals are of a brick red colour. The whole substance of the flower is not less than half an inch thick, and of a firm, fleshy consistence. Numerous specimens have been received in England.

*New Locality of Marble, &c. near Boston.*—We have lately visited a bed of limestone at Stoneham, eight miles from Boston, which promises to be a valuable quarry to the owner, and to afford many substances interesting to mineralogists in this vicinity. It appears that the existence of the limestone was known to a few individuals many years ago, and some rude attempts to convert it into quicklime were made. It was soon, however, abandoned, probably on account of the expense of fuel, and was nearly forgotten until the present owner, about forty years since, made some further attempts at working it. He soon, however, abandoned it, and it has remained almost unknown till very lately. We understand the right of working it has been purchased by a gentleman who proposes shortly to make a more extended examination.

The country in the vicinity of this *bed* (for such it will probably be found to be) is principally occupied by beds of hornstone and felspar porphyry, and sienite under various forms. The hills are numerous, but of moderate elevation, and with a gently rounded outline. The escarpment of some of the porphyritic hills, however, is sometimes nearly perpendicular. Large fragments and boulders are abundantly scattered over the country, but we have never noticed any limestone among them.

The excavations from which the limestone has been taken are as yet too limited to afford a good display of the structure of the formation; our account is therefore necessarily imperfect.

The limestone is covered by sienite and sienitic greenstone, varying in thickness, from one foot, or even less, to eight or ten feet. Epidote pervades all the rocks of the vicinity, and veins of it are exceedingly numerous in the sienite.

Much of the limestone is compact, highly crystalline, of a snow white colour, of a moderate degree of hardness, with a fine grain, and all the requisites of a superior marble. The upper part of the bed, near its junction with the sienite and greenstone, is siliceous and hard, passing indeed into hornstone, of a grey and a light green colour. The hornstone has often the character of iron flint, having a deep red, sometimes a crimson colour, it gives abundant sparks with steel, and is stained with dendritic delineations, probably of manganese.

The limestone is intermixed with, and passes into a green substance having all the external characters of saussurite; where it is free from this substance, it effervesces briskly with acids. The mixture of saussurite and limestone constitutes a hard and tough mass, which scarcely effervesces with acids, and is with difficulty polished. Some parts of the bed are abundant in tremolite, in white radii of considerable beauty, and green allochroite. [J. W. W.]

*Substitute for Indigo.*—It has been found that a blue dye can be obtained from the common hollyhock, or rose mallow, which is said to equal in beauty and permanence the best indigo.

*Method of preserving Echini, Asteriæ, &c.*—Colonel Mathieu, who has made a fine collection from the Isle of France, has found the best method of preserving the mucilaginous or membranous part of echini, asteriæ, crabs, &c. to be the application of dilute lime water before drying them. Echini were first emptied, and then the animal put into lime water for 12 hours, taken out and dried in the shade, and put in the same water for two hours, and then dried, the spires being preserved in their places by cotton. Asteriæ were put alive into lime water, and treated as the echini. Such as were fleshy had the flesh first removed.

With the crustaceous animals, as the crab, the head is first removed and dried in the shade, then the body and limbs emptied as much as possible. The specimen is then placed in lime water five or six hours, and then dried in the shade thrice successively. When dry, and having but little odour, the head is replaced, and the whole preserved in the shade. The colours are very little injured by the operation.—*Jour. de Physique.*

**Art. XIII.—*Remarks on the Insensibility of the Eye to certain Colours.*** By John Butter, M. D., F. L. S., M. W. S. &c. &c.; Resident Physician at Plymouth. In a Letter to Dr. Brewster. [*Edin. Phil. Jour.*]

My Dear Sir,

Knowing how much you have directed your attention to the subject of optics, and that every variation connected with the ordinary phenomena of vision is interesting to you, I transmit, without farther apology, the particulars of the following case, which my friend, Dr Tucker of Ashburton, Devon, has lately made known to me in the instance of his own son: About two years ago, Mr Robert Tucker, who is now aged 19, and the eldest member of a family of four children, discovered that he was unable to distinguish several of the primitive colours from each other. He was employed in making an artificial fly for fishing, intending to have constructed the body of the fly with silk of an *orange* colour, whereas he used that of a *green*. When the error was pointed out to him by his younger brother, he could not believe it, until it was confirmed by other persons. Threads of orange and green silk were then twisted round his finger, and he could not perceive any difference in them, but thought them to be the same coloured thread twisted several times. This circumstance led to a trial of his powers for distinguishing other colours, and the following are the results which have been ascertained, taken correctly by frequent repetition, and confirmed by the trials made in my presence. Many of the leading or primitive colours, he neither knows when they are shown, nor remembers after they have been pointed out to him. Certain colours are confounded with each other. Orange he calls green, and green colours orange; red he considers as brown, and brown as red; blue silk looks to him like pink, and pink of a light blue colour; indigo is described as purple. The seven prismatic colours seen in the Spectrum, are described in the following manner:

| Colours. | Colours. |
|---|---|
| 1. Red, mistaken for | Brown. |
| 2. Orange, | Green. |
| 3. Yellow, generally known, but sometimes taken for | Orange. |
| 4. Green, mistaken for | Orange. |
| 5. Blue, | Pink. |
| 6. Indigo, | Purple. |
| 7. Violet, | Purple. |

So that the *yellow* colour alone is known to a certainty. The colours were shown to him on silk, on feathers, and in Syme's book of colours, with uniform result. Red and brown colours appear the same, as well as green and orange, blue and pink, and indigo and purple. With the exception of black or white objects, which he seldom mistakes, all colours are by him divided into three classes, viz.

Class 1st, includes red and brown.
2d, blue, pink, indigo, violet, and purple.
3d, green and orange colours.

He can generally say, with certainty, to which of these three classes any colour belongs, but he mistakes one colour for another. A difference in the shades of green he can distinguish, though not the green colour itself from the orange. Soldiers' scarlet coats appear red. Grass looks green.* The colours of horses are quite unknown to him, except a white or black horse. A bay, a chesnut, and a brown horse, is described of the same colour. The colours of the rainbow or of the moon, appear nearly the same, being twofold; at least, two distinct colours only are seen, which he calls yellow and blue. A blue coat, however, he can distinguish from a black, but this circumstance may be owing to the metal buttons in the one coat, and not in the other; and a yellow vest is always known to him. By day, he called carmine red, lake red, and crimson red, purple, in Werner's book of colours by Syme; but by candle-light this error was detected, and the colours were called red with a tinge of blue. Black, which is the negation of all colour, could not be distinguished by him from a bottle-green colour, in one instance, though the difference was quite obvious to myself. Black, white, and yellow bodies are, however, recognised with tolerable certainty; though the shades of white, which again is but the beam of all colours, are not distinguishable. The shades of green can be distinguished from each other, as already stated, though none of them are known from orange. Duck-green, he called a red, and sap-green, an orange colour. If he closed one eye and looked with the other, the results were not altered. His health has been good. This defect has not sprung from disease, it bears no relation to nyctalopia

* It is remarkable that green, which is the softest of colours, and composed of yellow and blue, should be mistaken for orange on every substance except on grass.

or amaurosis only in its probable seat; it is natural, not morbid.

*Description of Eyes.*—Mr R. Tucker's eyes appear to be very well formed, being oblate spheroids with corneæ, neither remarkably convex nor flat. Irides light ash-colour. His vision is exceedingly acute. It has been frequently exemplified in finding bird's nests, in shooting small birds, and in reading minute print at a short or long distance. Light appears to him as light. He sees the forms of surrounding objects like other people at noon-day, in the twilight, and at night. In short, his sight is remarkably good in any light or at any distance. His grandfather, on his mother's side, seems not to have possessed the faculty of distinguishing colours with accuracy.

*General Remarks.*—Physiologists may speculate in opinion, whether or not this deficiency in the faculty of perceiving colours, as exemplified in the instance of Mr R. Tucker, depended on the eye as the instrument and organ of vision, or on the sensorium to which all impressions made on the retina of the eye are referred, and in which the faculty or power of discriminating colours is supposed to reside. Vision, regarded as a sensation, is only one medium of communication, which the brain or common sensorium has with the external world. The other senses afford other media. If an eye sees objects clearly, distinctly, and quickly, vision cannot be considered defective. The faculty, whatever it may be, wheresoever it resides, of discriminating the differences between different objects, certainly is not confined to the eye. The eye is but an optical instrument, serving to the purposes of vision; the judgment exercised upon the visual sensations, is an after process, and resides not in the eye. Still, however, the construction of the visual organ, modifies the appearances of objects presented to it. All eyes do not see equally well in the same light. Nevertheless, there is a standard of vision which we call common. A difference in the vision of eyes depends, not unfrequently, on the colours of the iris and tapetum. In Albinos, the iris is red. They cannot see distinctly in the day time, because the red rays of the sun are possibly reflected, while the rest may be absorbed. It is probable that the red rays may be reflected from the iris when most closed, in Albinos, because in them there is a deficiency in the pigmentum nigrum or black coating, which covers the choroid tunic, and which being wanting, allows the rays to be more reflected and less absorbed than they are in human

eyes generally. Hence the pupil is almost closed in Albinos. Red, we know, strikes the eyes most forcibly, as it is the least refrangible colour. In optics, it is proved that red bodies reflect the red rays, while they absorb the rest, and green colours reflect green rays, and possibly the blue and yellow, but absorb the rest. Still, however, the consciousness of colours does not depend on the colour of the iris, because one person having a dark iris, and another a light grey, can distinguish colours equally well; nor on the tapetum, by the same rule, though the use of this coloured matter in the eye, is not yet well made out. Herbivorous animals, as the ox, are supposed to have the tapetum in their eyes of a greener colour than carnivorous animals, in order to reflect the green colour of the pasturage: but this explanation, given by Monro *primus*, does not hold good, for the hare, whose tapetum is of a brownish chocolate, and the stag, which has a silvery blue tapetum inclining to a violet, is equally herbivorous with the ox. In man and apes, the tapetum is of a brown or blackish colour; in hares, rabbits, and pigs, it is of a brownish chocolate. The ox has the tapetum of a fine green-gilt colour, changing to a celestial blue; the horse, goat, and stag, of a silvery-blue changing to a violet; the sheep of a pale gilt-green, sometimes bluish; the lion, cat, bear, and dolphin, have it of a yellowish-gilt pale; the dog, wolf, and badger, of a pure white, bordering on blue. The use of the tapetum and of the pigmentum nigrum, can scarcely be said to be known. We can only infer, that the tapetum, if white, might reflect all the rays and absorb none, and if black, as in man, it should absorb all the rays and reflect none. "Il est difficile," says Cuvier, "de soupconner l'usage d'une tache si eclatante dans un lieu si peu visible, Monro et d' autres avant lui, ont cru que le *tapis* du boeuf est vert, pour lui representer plus vivement la couleur de son aliment naturel; mais cette explication ne convient pas aux autres especes." Cuvier, Leçons d'Anat. Comp. tom. ii. 402. Birds and fishes may perceive colours as well as animals, though they have no tapetum. The vision of man is regarded the most perfect, and defective vision in old people, is sometimes produced by a deficiency of the black paint. These considerations do not, however, lead us to suppose, that the faculty of distinguishing the harmony of colours depends on the eye, any more than the concord of sounds does on the ear. The eye and the ear can be regarded only as instruments for bringing the sensorium, or thinking principle of man and animals, acquainted with

whatever is visible or audible. The faculty, therefore, must reside elsewhere. Quickness of vision never made a Newton, nor delicacy of hearing a Handel, nor fineness of touch a Reynolds, nor acuteness of smelling a Davy, nor accuracy of taste any philosopher whatever. For all that man sees, hears, touches, smells, and tastes, constitutes only a specific difference in his sensations. These several sensations are compared, judged of, and distinguished from each other, by some internal principle which does not reside in the organs themselves. It is this principle or discriminating faculty of colours which is wanting in Mr R. Tucker. Pressure made on the optic or auditory nerves entering the brain, will paralyse these organs which can neither see nor hear, unless their communication with the brain be preserved. Amaurosis sometimes arises from disease in the brain, and deafness from a similar cause. The brain is the sensitive centre which feels all the sensations of light, sound, odour, and taste. In palsy, the latter is often annulled. In the instance of Mr R. Tucker, there is no evidence whatever, to lead a person to suppose, that defect exists in the functional office of his eyes, for his vision is quick above par. Where, therefore, does the fault lie? His eyes do their office, but the subsequent processes of perceiving, judging of, comparing, and remembering, (as confined solely to colours, his other faculties being perfect,) are deficient. We must seek the explanation, therefore, in physiological, and not in optical science, for the phenomena do not depend on the mechanical construction of his eyes. Yours, &c. John Butter.

*Observations on the preceding Paper.* By Dr Brewster.

From the facts described in this very interesting paper, Dr Butter has concluded, that Mr R. Tucker's imperfect vision of colours has a *physiological* and not an *optical* origin; and he proceeds in the conclusion of his paper, (which, we have omitted,) to fortify this conclusion by the statement, that Mr R. Tucker is particularly defective in the "organ of colours."

In giving an account of the case of Mr Dalton, and others, whose eyes have an imperfect perception of colours, Dr Thomas Young has remarked, (in opposition to Mr Dalton's opinion, that the vitreous humour of his own eye is of a deep blue tinge,) that "it is much more simple to suppose the absence or paralysis of those fibres of the retina which are calculated to perceive red."

With regard to the existence of fibres in the retina, suited to the perception of different colours, we have no evidence; but it seems quite sufficient for the explanation of the leading facts, to suppose that the retina is insensible to certain colours.

Dr Wollaston, in his interesting paper on sounds inaudible to certain ears*, has shown, that ears both of the young and old, which are perfect with regard to the generality of sounds, may, at the same time, be completely insensible to such as are at one or the other extremity of the scale of musical notes; and I have lately ascertained, that some eyes which perform all the functions of vision in the most perfect manner, are insensible to certain impressions of highly attenuated light, which are quite perceptible to other eyes. Dr Wollaston has given the most satisfactory explanation of this partial insensibility of the tympanum, and I conceive, that the insensibility of some eyes to weak impressions of light, requires no other explanation, than that either from original organization, or some accidental cause, the retina of one person may be less delicate and less susceptible of luminous impressions than the retina of another, without being accompanied with any diminution of the powers of vision. If a sound ear, therefore, may be deaf to sounds of a certain pitch, without our looking for the cause of this in the form of any part of the brain, why should we appeal to such an uncertain guide for an explanation of the analagous phenomenon of the insensibility of the eye to certain colours.

## Art. XIV.—*Account of the recent successful Ascent of Mont Blanc, by Mr F. Clissold.* [*Edin. Phil. Journ.*]

The following interesting account† of Mr Clissold's ascent of Mont Blanc, was transmitted to us by our friend Professor Pictet, through the hands of Mr Clissold himself, who has accompanied it with some important corrections.

We are glad to learn, that Mr Clissold has resolved, contrary to his original intention, to draw up a short account of his ascent, and we trust he will enter into the minutest details on a subject so extremely interesting. Mr Clissold

* See Boston Journal p. 26.

† Printed in the Bibliotheque Universelle, September, 1822.

has very handsomely resolved to transmit to professor Pictet, any profits that may arise from the publication of his narrative, for the benefit of the families of the three guides who perished in the unsuccessful attempt of 1820.

"Since the unfortunate ascent in which three guides of Chamouny perished, on the 18th of August, 1820, not far from the summit of Mont Blanc, being precipitated and buried in a cleft by an avalanche of snow, nobody had attempted this enterprise, which is as dangerous as it is useless, till a young English gentlemen (Mr F. Clissold) came from London to Chamouny with a firm resolution of attempting it. After having spent the first half of August at the foot of this formidable mountain, in expectation of favourable weather, he at last executed the ascent, on the 19th of August, with a success, and, above all, a celerity, of which none of the nine preceding ascents afford an example. He has transmitted some particulars of his expedition, in a letter to his banker, who has had the goodness to communicate it to us, and which the author himself, whom we have had the satisfaction of conversing with more than once, after his return to Geneva, has allowed us to insert in our work.

"*Chamouny, August* 27, 1822.—Sir, You have probably heard of the success of my ascent of Mont Blanc, of which I shall communicate to you some particulars. I left Chamouny, where I remained fifteen days in expectation of settled weather, on Sunday, the 18th, at half past 10 P. M., with six chosen guides, one of whom was provided with a lantern.* We ascended, as is usually done, by the mountain called De la Cote, and reached the summit of it at half past three in the morning. After a short halt, we entered, at four o'clock, on the Glacier; and, having crossed it without accident, reached, at half past seven, the rocks called the Grands Mulets, where preceding travellers have generally made arrangements for passing the night. My plan was different: I was ambitious to reach the summit the same day, and to remain there during the night, in order to see the day-break on the following morning. We therefore continued our

* Each of these guides carried a weight of 20 lb. in provisions and objects of precaution for the ascent. Mr Clissold, either with the design of trying his strength, or with the view of inspiring the guides with confidence, carried one of these loads during a considerable part of the ascent of the mountain De la Cote.

march, the most difficult part of which was in the neighbourhood of these same rocks, where we had to climb obliquely up a very steep slope of ice, inclined about 45 degrees, in which we were obliged to cut with a hatchet a number of steps, the missing of one of which would have been certain death; for this slope terminated at an enormous cleft. This passage was still worse when we came down again. We quitted the Grands Mulets at nine o'clock, and reached at two the Grand Plateau, near the Dôme du Gouté. We were in the region of those masses of snow, which are formed into enormous parallelopipedons, called Seracs. Thence, ascending to the left, we from time to time proceeded along the edge of the clefts, one of which was perhaps the grave of the victims of 1820. All the guides, excepting P. M. Favret, and myself, were more or less incommoded by the rarefaction of the air. Three of them, in particular, who ascended Mont Blanc for the first time, lost their strength to such a degree that they considerably delayed our progress. If it had not been imprudent to separate, I should certainly have reached the summit before night. We arrived about seven in the evening at the Petit Mulet, a rock situated above the Rocher Rouge, the nearest to the top of all those that are seen from Chamouny. We had reached it at half past six. The Petit Mulet being higher, and to the left, is not visible from below. As we had not time to reach the summit before night, we descended again to the Rocher Rouge, near which we made a pit in the snow, four feet deep, five broad, and six long. We placed at the bottom some pieces of wood, on which we spread a rather thin covering, on which we all seven lay down, covered with a slight sheet, which was by no means sufficiently large for the purpose. Some blasts of wind, which now and then blew into our faces some of the light snow drifted from the surface, was a bad omen of the fate that awaited us if the wind had risen. We slept, however, about four hours. We could not observe the thermometer for want of light; but the night was cold enough to produce ice in a bottle of hermitage wine, and thoroughly to freeze some lemons among our provisions. The right foot of one of my guides (David Coutet) was frozen, and also the extremities of my own fingers and toes. But these accidents were attended with no bad consequences. We left our cold couch at four o'clock in the morning. The day was beginning to break, and the first rays of the dawn gave a silver tinge to the summits, from which we were not far distant. In pro-

portion as the sun approached the horizon, the tint changed, and became entirely golden when he rose. It formed the most striking contrast with the nearly black colour of the sky, from which it seemed to be detached. All the difficulties were now surmounted: we sunk but little in the snow, and now and then halted for a short time to take breath. We soon came to the Petit Mulet, which we had visited the day before; and at half past five we were on the summit. We began by making the signals agreed on with our friends in the plain, who easily distinguished them.

"This summit is not so limited as it seems to be at a distance. It forms a small plain, nearly horizontal*, which is in the shape of a triangle, the base of which is towards Chamouny; one side is towards the Allée Blanche, and the other towards the passage of Bon-homme. It took me four minutes to walk along the perpendicular drawn from the apex of the triangle to the base.

"The sky was without clouds; the sun, which had risen below our horizon, deluged with light the region from which it seemed to issue, and in the direction of which we could distinguish nothing. Every where else we perceived a vast number of summits, some covered with shining ice, others more or less rent and threatening: others, again, of roundish forms, and covered with pasture. Jura bounded the horizon in the N. W.; more to the north we saw the lake, but not Geneva. To the S. E. the eye penetrated beyond the plains of Lombardy, as far as the Apennines, which bounded the horizon in the form of a blue line, or of the dense fog of a winter's morning. The sun, both at setting the preceding evening, and at rising in the morning, seemed more or less enveloped in this vapour. I had brought no instrument with me but a thermometer. At sun-set the day before, near the Rocher Rouge, it was at 26° Fahrenheit. We forgot to observe it when we set out in the morning; but Coutet, who is used to making observations at great heights, thinks that the cold exceeded 18° Fahrenheit. But on the summit at eight o'clock; at the Grands Mulets, the day before, at nine; and the Grand Plateau, the same day, at three; lastly, at the Grands Mulets the next day (Tuesday, about three in the afternoon);—at all those stations the thermometer observed by Coutet, and one at four or five feet from the ground, stood at 70° Fahrenheit.

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* About 200 feet fall. (F. C.)

"During our stay on this singular *belvedere*, some of the guides picked up specimens of the highest rocks near the summit, which I brought along with me. After stopping three hours on the summit, where I felt myself very comfortable, except that I had lost my appetite since leaving the Grands Mulets, though the guides had preserved theirs, we set out for the purpose of descending. It was half past eight o'clock. At eleven, we came to the Grand Plateau, and at half past one to the Grands Mulets. When we arrived there, we heard something like the rolling of thunder, which was nothing but the noise of an enormous avalanche, which was seen from the Col de Balme, to cover a part of the space which we had crossed in our descent. A few hours sooner, and we should have all been enveloped and destroyed.

"We quitted the Grands Mulets at three o'clock, and at half past three were beyond the region of the ice. We arrived at the Priory of Chamouny at half past seven, after an absence of forty-five hours.

"We there heard that two English ladies (Mrs and Miss Campbell) had passed the Col du Geant, two or three hours before we reached the Petit Mulet, and that while we were near that rock, they were descending at Cormayeur. They had left Chamouny on Sunday, and spent the night at the foot of the rocks of Tacul. In consequence of the ignorance of their guides, they met with more difficulties than I experienced. They are resolved to attempt, next year, or the year following, the ascent of Mont Blanc.

"I owe so much of my success to Joseph Marie Coutet, that I wish to present him with a portable barometer, made by your excellent artist M. Gourdon, and I beg that you will endeavour to obtain it for him as soon as possible.

"I am much indebted to you for having procured me the acquaintance of M. De Saussure, and the inspection of the shoes which his late father wore at the time of his ascent. I got mine made upon the very same plan, and they enabled me to cross rapidly the Glacier of Boissons, and to pass where the guides could not follow me. I walked, indeed, with these shoes upon the hardest ice, as if I had been upon the solid ground*."

* These shoes have the soles sufficiently thick to receive nails of steel, cut with a square point, and the other end of which has a screw, which is fixed in the leather, on which rests the base of the pyramid, which forms the head of the nail. The steel is tempered, and brought back to a straw colour, which leaves it almost all its hardness, and renders it less liable to break.

The following are the names of my guides:

Joseph Marie Coutet, the chief. This was his sixth ascent.

David Coutet, his brother. This was his fourth ascent.

Pierre Marie Favret, the strongest of them all. This was his third ascent. His father formerly ascended with Saussure.

Jacques Coutet, another brother of Joseph.<br>J. Baptiste Simon.<br>Matthieu Bossnet. } This was their first ascent.

*Note by Professor Pictet, on the Specimens from Mont Blanc.*

Mr Clissold has had the goodness to show us his specimens, andgive us duplicates of the most interesting.

No. 1. Is the fragment of a rock *in situ*, nearest the summit, that is, the highest point of Europe. It is an amorphous rock, in which felspar predominates, mixed with a little quartz. It is yellow here and there with oxide of iron.

No. 2. Is a specimen of those rocks with vitreous bubbles on the surface, which are commonly found on the Aiguille of Gouté, and of which Mr Clissold has brought a great number from the summit of Mont Blanc. The one in question is composed of a mass of black amphibole (hornblende,) almost pure, to which adheres a distinct crystal of felspar. At the place where the two substances come in contact, are seen three or four globules of black glass, one of which is about a line and a half in diameter, and from this runs a slight groove, excavated out of the felspar portion of the stone, and in which there are small globules of black glass, an effect which seems to confirm the opinion of those who attribute these fusions to lightning.

No. 3. Is a small specimen of the same kind of rock, but in which the felspar is more disseminated. Two faces of the stone are wholly covered with microscopic vitreous globules, and one of its two faces, seen with a microscope, appears entirely covered with a varnish arising from fusion.

No. 4. Is a fragment of rock of the Grands Mulets, covered with small crystals of Adularia, intermixed with Amianthus*.

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* Mr Clissold, we understand, means to deposit the greater part of the specimens in the British museum, and in that of the Geological Society.

## Art. XV.—*On certain Elevations of Land, connected with the Actions of Volcanoes.* By J. Mac Culloch, M. D., F. R. S. *Communicated by the author.* [*Jour. of the Roy. Ins.*]

(Continued from p. 31.)

I must now proceed to consider the case of the coral islands, as offering the same proofs of the elevation of submarine strata by the action of volcanic force. These also, which appear to be of dates considerably distant, serve to connect the catastrophe which generated Italy as it now is, with those which, in Pliny's time, formed the Greek volcanic islands, and with the more recent ones, which in our own have produced the new islands of Iceland and the Azores.

The production of the coral islands which are scattered over the great Pacific ocean, which endanger the navigation of the Indian Archipelago, and which, by their daily increase, are ruining that of the Red Sea, is a phenomenon completely distinguished from all the others which are objects of geological investigation. By the silent and almost unnoticed operations of the minutest animals of creation, the foundations of new lands are daily preparing under the ocean. Nor, as in the case of other submarine formations, are these operations limited to the germs of future and distant continents and islands, and destined only for the habitations of races in the far remote and merely possible future. In consequence of the instincts of these animals, assisted by other causes, which will presently be described, the rocks which they form become elevated above the sea without the necessity of those actions which have raised other submarine strata from below. Thus daily additions are made to the habitable surface of the earth, and islands gradually arise in the wastes of the ocean, enlarging the dominion of man, and promising to unite the remotest continents in the bonds of mutual intercourse.

Independently, therefore, of the proofs which some of these islands afford, of elevating forces connected with volcanoes acting beneath the surface of the earth, the simple fact itself forms an interesting and necessary branch of geological inquiry; and the more so, because it has hitherto experienced unaccountable neglect among geologists. It cannot be less interesting to study the formation of immense masses of calcareous rock, by living animals, than by the accumulation of the spoils of dead ones. It is in many respects even more so: no less from the illustration it affords respecting the an-

cient calcareous rocks of the globe, than from the tangible nature of what, in these analogous cases, is only matter of inference, and from the apparent feebleness of the agents concerned in the production of these most important effects.

With respect to all the organic fossils, their chief interest is derived from the relations which they bear to the existing species, and from the effects which they have on the structure of the earth. We are surprised at the immense accumulation of shells which form the secondary calcareous strata, or which, if they do not actually produce these, contribute most materially to their bulk, as well as to their chemical nature: and, in examining them, we cannot help being struck with the immense additions which the solid crust of the earth has received from the labours of animals which, employed only in forming their own habitations, have, in the progress of time, generated mountains; as we may safely say, when we examine the enormous strata into which they enter as principal and constituent parts.

Still, however, these do not make that impression on us which they ought; because, seeing these rocks as we do, mixed with others, long deserted by the sea and by their former inhabitants, and now divested of all marks of life, and except to the eye of a geologist, of all indications of their former origin, we are apt to pass them by, and think that the surface of the earth might have been nearly the same had these animals never existed, or had they remained at the bottom of that ocean where they lived and died. But when we trace this very act in its progress; when we follow with our eyes the increments which the land is actually undergoing in consequence of the labours of submarine animals, we receive a very different impression respecting their importance; and, in watching the hourly formation and increase of the coral islands, begin to be more sensible of the vast importance of this race of beings, and of the immense changes which all the marine tribes must have produced on the chemical nature, as well as on the structure and disposition, of the superficial or more recent strata.

With respect to the operations of shell-fish, we know that they are now forming immense strata under the waters, just as they must have done in times long past, and before they could have produced the rocks which we now behold above the ocean. Whether these are ever destined to rise above the sea, or when that may happen, we cannot even conjecture; although, were we to reason from analogy derived from past

events, we should conclude it was probable, unable as we are to assign the mode in which such an event is to be brought about. Should it happen, new calcareous strata will be found on the surface of some future earth, and the fossil remains of those days will be what were the living species of our own.

But when we examine the operations of the coral animals, we find in them that which we cannot in those of the shellfish. In the latter we can only infer from observation and analogy, that the immense masses of our present calcareous strata have been thus produced. We transfer from the bottom of the sea those operations which we know to be daily going on; and reasoning on them, recur to a time when our limestones were in the same act of being formed, and were preparing for future dry land; land to be laid dry by its own elevation, or by the receding of the waters, as geologists shall hereafter agree or prove. But there is a perfect and complete chasm between the two, at least in the case of marine strata. In the terrestrial or fresh water ones it is otherwise; as we can follow the marly deposit of a lake till it rises to the level of the water, and, gradually excluding it, prepares the dry land; an operation of which every country, and our own mountainous region as distinctly as any, affords daily proofs in the marl deposits, covered with soil and peat, that are found throughout the Highlands of Scotland.

In the coral formation, this chasm, even as to the marine strata, is filled up. Such is the nature of the animals in this case, that instead of spreading their manufactures, if I may use such a word, along the bottom of the ocean, as the shellfish do, and concealing their stupendous works far beneath the regions accessible to man, their tendency is to seek the surface of the sea. There the huge strata which they produce are brought to light, even during their own and our existence, and we become acquainted with rocks that may be considered as fossil and living at the same time. When once the animals have deserted their habitations, when these have reached, as they do, above the surface of the water, and even far up into dry land, into islands of great extent, they must be considered fossil productions, as much as any other calcareous strata.

It appears that each coral, whatever its species be, is a solid calcareous structure, somewhat resembling a vegetable in the general progress and increase of its parts, inhabited by numerous similar animals, which are precisely the same for

each individual coral, but different in the different species. Each of these corals may thus be considered as a colony, the inhabitants being disposed in minute cells, where they reside and carry on the operation of extending their habitations. In these operations, however independently each seems to act in the production of its own cell, or in the extension of its own immediate neighbourhood, the whole are regulated by some common mysterious principle, by which they all concur towards the production of a structure that would rather seem to have been directed by one mind. Now nothing very analogous to this takes place in the animal creation, except in the case of the gregarious insects, that construct a common habitation for breeding, such as the bees and the ants. In these there is a possibility of personal communication; and that there is such, is proved by the accurate researches of many naturalists. No such communication can take place among the coral animals, because each is fixed and rooted to its cell, of which it forms a part. It may be considered, indeed, that the whole of the colony are parts of the structure which they inhabit, just as flowers are of a plant.

This analogy is very strongly confirmed by attending to the genus *vorticella*, a soft animal, incapable of constructing such a habitation as the coral, yet possessing some very striking analogies to it. The simple vorticella is independent, and swims at liberty; not unaptly resembling, at the same time, a flower, or a bud just expanded; appearing to consist of a body resembling a calyx, provided with tentacula, that have been compared to stamina or petals. But if we proceed from the simplest vorticella onwards, we find a species which is immoveably fixed, by a pedicle of animal fibre, to the spot where it was produced, or is at least only capable of floating through the water within narrow limits. In further progress, two are united by one stem, and at length there are found one or more species, in which a single stem produces numerous ramifications, each of which is terminated by the calyx-shaped animal, or flower, if we may so call it. In this case, each animal is partially independent, yet all depend on the whole; so that were it not for the demonstration of its being of an animal nature, it might be esteemed a vegetable. In what way this mutual dependence and co-operation of many animals, to produce a common structure, is managed, we cannot conjecture: but it might be imagined, did we not know the independent and single vorticella, that the ramous one was itself but one animal, and that the flowers, or single vor-

ticellæ, were only its parts. The whole dependence presents a singular analogy to the vegetable identity, where all the leaves and flowers conspire together to produce and propagate the plant; so as almost to lead us to conclude that there was here a perfect gradation from one department of nature to the other.

This explains the dependence of the coral colony, as far as one difficulty can explain another. The only difference consists in the hardness or softness of the habitation, or tree, if it may be so called. In the vorticella it is a soft animal matter; in the coral it is bony, or stony. And here also even the corals present an analogy to those vegetables which, like the chara and the coralline, incrust themselves with calcareous earth, or to the equisetum, which secretes a siliceous bark.

To take the inhabitant of the madrepore as an example of the animal itself, it may be considered as formed of the shell, the head, a centre, and the feet or hands: the latter are very numerous, and are divided or split at the extremities, while they surround the body of the animal in the form of a circle. Each of these feet or hands embraces a lamella of the star of the madrepore, so that they serve both for the construction of the shell, and for fixing the animal in it. The pedicle, or single part of the hand, appears to be of a muscular nature, and is fixed in a cylindrical tube, which is properly the body of the animal. Within this is a stellated body, which is supposed to be the head, quick in its motions; while the rays seem to be the tentacula by which it feeds itself.

The different species of corals engaged in the formation of the coral banks are not all known; but some of the genera, at least, and a few of the species, have been ascertained. The chief of these are madreporæ of different kinds; milleporæ, among which the cœrulea has been discovered; the tubipora musica; a caryophyllia, a distichopora, and a corallina. Astreæ, echini, and other animals, living and dying on the banks, add to the heap of calcareous matter, without being properly concerned in the erection of the structures. Frequently also, holothuriæ, and other soft worms, are found in the reefs, and have, by careless observers, been mistaken for the coral animals.

To describe, or even to enumerate, the different islands and rocks which owe their existence to the labours of the coral worms, would be to enter on a wide field of geography. The narratives of many navigators, such as Cook, Kotzebue, Flinders, and others, may be consulted by the reader, who is

desirous of more minute information on this subject; as it would exceed the necessary limits of this communication, to go into it in any detail. A very brief notice of a few remarkable examples is alone admissible.

Nearly all the islands that lie on the south of the equator, between New Holland and the western coast of America, derive either the whole or a great part of their structure from these animals. The whole of that sea, and indeed of some others, abounds in coral rocks and reefs, which are in a state of daily and rapid increase, and are probably destined at some future day to elevate themselves to the level of the water; to become first the seats of vegetation; and, in process of time, the habitations of man; and perhaps ultimately to produce scarcely less than a continent in this extensive ocean.

Among other places, these reefs abound particularly between New Holland, New Caledonia, and New Guinea; and they are well known to exist in great abundance in the seas of the Indian Archipelago, as at Chagos, Juan de Nova, Cosmoledo, Assumption, Cocos, Amirante, and the Laccadive and Maldive islands. They are numerous also, in the east side of the gulf of Florida; and it is well known that they form a daily increasing impediment to the navigation of the Red Sea.

The extent of these reefs and islands is an object of great curiosity and surprise when we consider the apparent feebleness of the means by which they are produced, and the minuteness of the agents. An instance or two of this must suffice here. Tongataboo, described by Cook under this misapprehended name, is an irregular oval of twenty leagues in circumference, while its elevation above the level of the water, reaches to ten feet. The soundings, from which the thickness of this bed of rock might be estimated, have not been given, but these are known to be deep throughout all this sea, and may safely be taken at not less than a hundred fathoms; so that the whole forms, what may be considered an enormous stratum of organic limestone. But the largest which appears to have been ascertained is the great reef on the east coast of New Holland, described by Flinders, which extends unbroken for a length of 350 miles; forming, together with others that are more or less separated from it, and from each other, a nearly continuous line of 1000 miles, or more in length, with a breadth varying from twenty to fifty miles. Before such a mountain of limestone as this, even the Apen-

nine almost shrinks in the comparison; and that such a mass should have been produced by such insignificant means, is a just subject of admiration to philosophical minds, and of wonder to those which have not considered the indefinite powers of units in endless addition.

Although the greatest depths of these submarine mountains have not been ascertained, they have been sounded to 200 fathoms and more. It is not uncommon for navigators, to say that they lie in depths that are out of sounding: a vague mode of expression among mariners, as it is now known that the lead can be sent down without difficulty even to a thousand fathoms. The reefs, or the islands which they form, are sometimes disposed in rows, or in lines more or less straight: at others, they are accumulated in groups; and not unfrequently, they are disposed in a circular or oval manner; the latter disposition, whether on the small or great scale, having a material influence on the form and nature of the future island.

It is imagined, that their generation is very rapid; but on this part of the subject there is some uncertainty, while there is also reason to think that it has been somewhat exaggerated. These seas cannot, from their extent, be intimately known; nor is it possible that the infinite numbers of the reefs that exist in them should have been noted down. Even if they had, it is always an excuse for an incorrect chart, or, as in the case of the Alceste, for a bad reckoning, to assert that a new rock was found where the old one had been overlooked.

On examining the soundings of the seas in which they lie, and on comparing their positions, it appears probable that the various dispositions, as well as the places of the reefs, are in a great measure determined by the forms of the submarine land, and that they are placed on the tops of the hills, or on the most elevated parts of the bottom. When they form straight or curved lines, the side of the submarine structure to windward, or that which is exposed to the breach of the sea, rises almost vertically in the manner of a wall; while to the leeward, they shelve gradually away, so as to deepen the water as they proceed in this direction, when, at the other side they have reached its surface. It is supposed that there is here some design for effecting a purpose which it is thought that accident can scarcely have determined; and that the intention of the animal in thus building up to the windward, was to procure shelter for continuing its productions to leeward. Whatever may be thought of that supposition, it is this abrupt manner of rising from the bottom which ren-

ders them so dangerous to ships; as, from deep soundings, they may in a moment be on shore, and almost without warning.

When the groups are circular, there are some peculiarities in them, as well as in the results, which are worthy of notice. A number of detached rocks and islands are first observed, forming a chain, which becomes gradually united in different places, so as to hold out the prospect of its becoming continuous at some future day. All round this, on the outside, the water is deep, and the walls vertical; but within, it is found to shoal in different places, so as to convey the idea of a large platform, surrounded by an elevated margin, with a depression in the middle. In the smaller circles, when this process is completed, the reefs represent a circular basin. This basin continues to be salt, and is a receptacle for sea water for some time, during which it continues to grow shallower gradually, as the animals within it prolong their operations upwards. But as the water shoals, and the rain falls into it, it at length becomes freshened, so that the animals die, and the operation of filling it up ceases. Thus it becomes a fresh-water lake, and forms that receptacle which is so common a feature in all the flat islands of those seas.

Of whatever size the circle may be, but particularly if it be large, the islands begin first to collect on the outside of the reef, while within it, projecting parts, or banks and rocks, are scattered in different places. The ridge, or dam, to windward, under the protection of which the whole mass extends, is produced by the fragments of the corals. Whenever they have arrived at the surface of high-water mark, they cease to grow any longer, as the animal cannot live out of the water. But at low water, the reef is of course above the sea. Thus the force of the waves breaks off the upper parts, and washes them onwards to leeward, where they collect; while the animals, still working upwards on the windward side, keep up a constant supply of materials destined to the same end. Thus a bank of dead matter, or of fragments and sand, produced by the wear of the corals, is formed on the top of the living rock, and cemented by the solvent power of the water on the carbonate of lime. In this manner, it is raised above the level of the high-water mark, and kept smooth by the surf which continually breaks over it, until it is elevated even beyond the reach of the sea. The sand and fragments in time consolidate, so as to produce regular strata, resembling the calcareous rocks of Gaudaloupe, Bermuda, Bahama, and other

West India islands; and fragments of these, forming large blocks of stone, are frequently piled up in the ridge, and even further onwards, till a large extent of surface becomes thus consolidated by the aid of more sand and fragments, and sometimes by that of shells also, into a solid mass of land. As the same process is also going on in the interior parts, where the projecting banks lie, all these at length extend and unite; so that islands of any magnitude may in this manner at length be produced. Occasionally, the lakes before-mentioned, are also filled up by the growth and decomposition of vegetables, becoming first marshy spots, and at length dry land. Had it not become a sort of fashion in philosophy to omit all consideration of final causes, I might here point out the singular and beautiful arrangement thus made for providing fresh water for the eventual inhabitants of islands, which from their necessary want of springs, or other modes of supply, could never have become the residence of man; of the improvident being at least, whose lot it must be to commence the population of these new regions.

The remainder of the operation is to clothe these islands with soil and vegetation. This is the work of time, yet it is more rapid than would be expected. The first foundation of it is laid by the sand which the sea produces from the destruction of the corals, and by the sea plants which take root and grow upon it. Sea birds, finding a place to settle in, add something; and at length the seeds of various plants floating about the ocean are arrested and begin to grow, when a vegetable covering succeeds. Among these plants, the most conspicuous are the Scævola, Pandanus, Cerbera, Morinda, Hernandia, and others, which first begin to grow in the outer bank, where their seeds were originally arrested, and at length spread over the whole. Last of all comes Man, and the island forms a part of the inhabited world.

It is evident, that islands formed on this principle, can have no great elevation above the water; and accordingly, those which are entirely flat, are scarcely elevated more than five or six feet above the high-water mark. But as many of them are higher, it is necessary to resort to some new principle for effecting this purpose. This principle is that action of a subterraneous elevating force, which forms the main object of this communication; and by means of which the phenomena of the coral islands become connected with those of the Italian alluvia.

Tongataboo, already mentioned, is ten feet above the high-water mark; which is a greater elevation than can be produced by the action of the sea, supposing that the whole of that space consisted of fragments such as have been described, and not of perfect corals, which cannot raise themselves to the least distance above the sea. But Captain Cook observed in many islands, that the corals, with all their characters as perfect as if they had been alive, were found at elevations of even a hundred feet above this. It is very certain, that the ocean could not have been depressed by that quantity, or rather that it never could have stood a hundred feet higher than it does at present; so that we must conclude that this island has been elevated. Though certain geological theorists should even choose to imagine this, there are still sufficient proofs here of the elevation of the submarine land. It is not difficult to trace the causes to which this is owing, which have effected in the bottom of the ocean, the changes necessary for the production of these results: and it will be seen, that they must have depended on the action of volcanic powers. We shall be at no loss in discovering the actual existence of this cause in many places, but the following islands will afford as convenient and satisfactory proofs of it as any other.

If we take the two islands of Tongataboo and Eeooa, we shall find that they form the first link in this chain, and one which is peculiarly valuable, from the proximity of these two tracts of coral land. Eeooa is separated from the former by a distance of only twenty miles. This island consists of a hill of considerable elevation, although its height is unfortunately not given in Cook's narrative. This omission, however, is not of any moment for the present purpose, as the essential circumstance is, that coral was observed on it at 300 feet above the level of the sea, continuing to near the summit. The soil above the coral is described as consisting of a soft yellow sandstone and a reddish clay. Now the position of the coral here is such as, even in a greater degree than in the preceding instances, to indicate the former existence of a force which must have raised it to that height above the level of the sea. From the proximity of these two islands, it is also probable that both of them were raised by the same force, and at the same time; and that the chief power was exerted under Eeooa, while the much lower island of Tongataboo was raised to so inconsiderable a height, comparatively, because it lay on the verge, or towards the evanescent margin of the expansive and elevating force. No other cause is

adequate to the production of these effects, and it is evident that the action which produced the greatest, is also capable of accounting for the least, of these.

Now, although it may be said that no volcano exists in Eeooa, and that such a cause cannot therefore be admitted, it will be sufficient to show that volcanoes have in other instances, and in this sea, exerted that very action, and in such a manner, that the coral rises upon the sides of the volcanic mountain; proving, in these cases, what may safely be inferred in the others, that it is not only capable of producing the required effects, but that, in these instances, it has actually produced them. That force, therefore, which has exerted its action, so as entirely to erupt the volcanic matter, may well be allowed to have also exerted that much less one, which was sufficient, as in the case of earthquakes, to alter the level of the submarine land.

It is possible that the volcanic action may here have been exerted under Eeooa itself, as the nature of the summit of the hill is not described by Cook. On other occasions he has neglected to notice volcanic rocks where we now know that they exist; and this is a subject which did not excite the attention of Mariner. But whether this be the case or not, the presence of a volcano in this group of islands is established. Toofooa contains one which is always burning, and this island is only seventy miles distant from Tongataboo. The small island Kao, about three miles from Toofooa, is also described as a cone, so that it is probably also of the same nature.

There is indeed reason to think that a volcanic force has been exerted very extensively in this part of the south Pacific Ocean. In Cook's arrangement, upwards of 150 islands are associated under the term Friendly Isles, and of these thirty-five are hilly. Otaheite, in the same sea, is of this form, and so are Bolobola and Eimeo. Though he has not mentioned volcanic rocks among these islands, it is now known that they occur in many places, and there are three burning volcanoes even in the Friendly Isles.

In further confirmation of this view, Eap, which lies to the westward of the Caroline Islands, is a seat of volcanic energy. Earthquakes are here frequent and violent, according to Kotzebue. He further remarks, that when Ulea trembles, all the coral reefs in the vicinity are shaken. In the north Pacific also, coral is found in Owhyhee, inland and above the sea; and in this island, Mouna Roa, and probably all the

rest of this lofty mountainous group, are formed of volcanic rocks.

These facts complete the chain of evidence in a manner that must satisfy every reasoning mind as to the ceuses which have raised, even the lowest of the elevated islands, above the level of the ocean. It is unnecessary to enlarge on a question so obvious. But the elevation of volcanic islands in other seas, mentioned at the commencement of this paper, serves to illustrate and confirm these reasonings. Those phenomena which have been detailed in the first division of this article, confirm also, as they receive illustration from that which has now been described. In the same way the changes in the level of the land adjoining tò many well known terrestrial volcanoes, which have been accompanied by the tremendous phenomena of earthquakes, would also serve to establish the truth of this explanation, could any further confirmation of a conclusion so obvious be required.

In terminating these remarks on the coral islands, it will not be uninteresting to observe, that analogous appearances occur in the volcanic islands of the African coast. Secondary limestones are found lying upon those rocks, which are the produce of fire, containing marine remains, yet elevated above the surface of the ocean. If the elevation of these strata, abstractedly considered, should be thought to prove nothing more than what may be inferred from the analogous appearances that are to be seen all over the world, it must be recollected, that there is here present, not only an obvious and active cause, sufficient to raise them from the bottom of the sea, but that the actual agency of that power in analogous cases, is proved by the phenomena of the islands now described. As far as it is a question of relative antiquity alone, there may be differences in the results, or in the present appearances; but the strength of the general argument derived from them remains undiminished.

As it is not here my object to extend these inferences to the general derangements and elevations of the strata of the globe, I shall leave the preceding facts to make that impression which geologists may permit, according to their several views or prejudices. But there remains a chemical question respecting the generation of coral islands, which is extremely obscure, but which is also highly interesting, not only as it relates to the production or collection of these enormous masses of calcareous earth, but as it bears on the formation of the ordinary stratified limestones.

Danube was pretty uniform throughout the twenty-four hours, being highest, 62° F. or 62¼° F. between 12 and 2 o'clock, and about one degree less before sunrise, and the temperature of the air from 61° to 73° F. during the day, and from 61° to 54° F. during the night. Below Passau, the Inn and the Ilz flow into the Danube.* On examining the temperature of these rivers at six o'clock, A. M. June 11th, that of the Danube was found to be 62° F., that of the Inn 56¼° F., and that of the Ilz 56° F.: the temperature of the atmosphere on the banks where their streams mixed, was 54°. The whole surface of the Danube was covered with a thick fog; on the Inn there was a slight mist, and on the Ilz barely a haziness, indicating the deposition of a very small quantity of water. About 100 yards below the place where the three rivers joined, the temperature of the central part of the Danube was 59° F., and here the quantity of mist was less than on the bed of the Danube before the junction; but about half a mile below, the warmer water had again found its place at the surface, and the mist was as copious as before the union of the three rivers. June 12th, the evening was cloudy, and the temperature of the atmosphere remained till after dark higher than that of the river, being, when the last observation was made, 63° F. when there was not the slightest appearance of mist. The sky was clearer before sunrise on the 13th, and the thermometer, immediately after sunrise, in the air above the river, stood at 55½° F., the temperature of the Danube being 61° F.; a thin mist was seen immediately above the river; but there being no mass of vapour to exclude the sun-beams, it rapidly disappeared, and was not visible a few feet from the surface; and in half an hour the whole atmosphere was perfectly transparent.

In passing along the Rhine from Cologne to Coblentz, May 31st, and June 2d and 3d, the nights being very clear, the same phenomenon of the formation of mist, was observed, precisely under the same circumstances; but as I could examine the temperature of the air and of the river only close to the banks, and in two or three situations, my observations were less precise and less numerous; the mist formed later in the evening, and disappeared sooner in the morning than on the Danube; which was evidently owing to the circumstances of the atmo-

* The Danube was greenish, the Inn had a milky blueness, the Ilz was perfectly pellucid; but from the rapidity with which the Inn descended, its waters at this spot gave their tint to the whole surface.

sphere being warmer and the river colder, the temperature of the one being from 66° to 75° F. during the day, and that of the river, where I examined it, from 59° to 60° F.

July 11th. I examined the temperature of the Raab near Kermond in Hungary, at 7 o'clock, P. M. and found it 65° F., that of the atmosphere being 72° F. During the whole evening there were some thin fleecy clouds in the western sky, which being lighted up by the setting sun, greatly interfered with the cooling by radiation from the earth, and at half past nine, the thermometer, in the atmosphere, was still 69° F. and at half past ten 67° F., when there was not the slightest appearance of mist. In the morning, before sunrise, the temperature of the atmosphere on the banks was 61° F., that of the river 64° F., and now the bed of the river was filled with a white thin mist, which entirely disappeared half an hour after sunrise.

I made similar observations on the Save in Carniola, in the end of August; on the Izonzo in the Friul, in the middle of September; on the Po near Ferrara, in the end of September; and repeatedly on the Tiber, and on the small lakes in the Campagna of Rome, in the beginning of October; and I have never in any instance observed the formation of mist on a river or lake, when the temperature of the water has been lower than that of the atmosphere, even when the atmosphere was saturated with vapour. It might at first view be supposed, that whether the cooling cause existed in the water or the land, the same consequences ought to result; but the peculiar properties of water, to which I referred in the beginning of the paper, render this impossible. Water in abstracting heat from the atmosphere becomes lighter, and the warmer stratum rests on the surface, and its operation in cooling the atmosphere is extremely slow; besides, the cooled atmospheric stratum remains in contact with it, and water cannot be deposited from vapour, when that vapour is rising into an atmosphere of a higher temperature than its own; and the law holds good, however great the difference of temperature. Thus, August 26th, at sunset, the day after a heavy fall of rain, and when the atmosphere was exceedingly moist, I ascertained the temperature of the Drave near Spital in Carinthia, and though it was 14° F. below that of the air, yet the atmosphere above the river was perfectly transparent.

It may be imagined, that without any reference to the cooling agencies of air from the land, mist may form upon rivers and lakes, merely from the loss of heat by radiation from the

air, or the vapour itself immediately above the water; and that the phenomenon is merely one of the formation of vapour, the source of heat being in the water; and its deposition, the source of cold, being in the atmosphere; but it is extremely improbable, that air, or invisible vapour, at common temperatures, can lose any considerable quantity of heat by radiation; and, if mist could be formed from such a source, it must always be produced to a great extent upon the ocean in calm weather during the night, particularly under the line, and between the tropics, which the journals of voyages sufficiently prove is not the case. I have myself had an opportunity of making some observations which coincide with this view. During a voyage to and from Pola, I passed the nights of September 3d, 5th, and 6th, off the coast of Istria; there was very little wind on either of the nights, and from sunset till nearly midnight it was perfectly calm in all of them. On the 3d it was cloudy, and the lightning was perceived from a distant thunder storm, and the vessel was never far from the shore: but on the 5th and 6th the sky was perfectly clear, and the zodiacal light, after sunset, wonderfully distinct and brilliant, particularly on the 5th, and we passed by the help of oars from two to eight miles from the shore. The temperature of the sea at sunset was 76° F., on the 5th 77° F., on the 6th, that of the atmosphere immediately above it, 78° and 79° F. On the 5th at midnight, about five miles from the shore, the temperature of the sea was 74° F. and that of the atmosphere 75° F., and on the 6th, at the same hour, at about four miles from the shore, the temperature of the sea was 73° F., and that of the atmosphere 75° F. There was not the slightest appearance of mist on either of these nights on the open sea, or at any distance from the land: but close under the hills of Istria there was a slight line of haze visible before sunrise, which was thickest under the highest land; and as we approached at sunrise, on the 7th, the mountains of the Friul, the tops of those nearest to Trieste were seen rising out of a thick white mist, which did not reach a quarter of a mile from the shore.

After mists have formed above rivers and lakes, their increase seems not only to depend upon the constant operation of the cause which originally produced them, but likewise upon the radiation of heat from the superficial particles of water composing the mist; which produces a descending current of cold air in the very body of the mist, whilst the warm water continually sends up vapour: it is to these circumstances, that the phenomena must be ascribed of mists from a river or

lake, sometimes arising considerably above the surrounding hills. I have often witnessed this appearance during the month of October, after very still and very clear nights, in the Campagna of Rome, above the Tiber, and on Monte Albano over the lakes existing in the ancient craters of this extinguished volcano, and, in one instance, on the 17th of October, before sunrise, there not being a breath of wind, a dense white cloud of pyramidal form was seen on the site of Alban lake, and rising far above the highest peak of the mountain, its form gradually changed after sunrise, its apex first disappeared, and its body, as it were, melted away in the sunbeams.

Where rivers rise from great sources in the interior of rocks or strata, as they have the mean temperature of the climate, mists can rarely form upon them, except in winter, or late in autumn, or early in spring. In passing across the Apennines, October 1st, 2d, and 3d, 1818, there having been much rain for some days preceding, and the nights being very clear, I observed the beds of all the rivers in the valleys filled with mist, morning and evening, except that of the Clitumnus near its source, in which there was no mist, and this river rises at once from a limestone bed, and when I examined it, at half past six o'clock, A. M. October 3d, was $7\frac{1}{2}^0$ lower than the atmosphere. Great dryness in the air, or a current of dry air passing across a river, will prevent the formation of mist, even when the temperature of the water is much higher than that of the atmosphere: thus on the 14th of June, near Mautern, though the Danube, at five in the morning, was 61° F. and the air only $54^0$, yet there was no mist; but a strong easterly wind blew, and from the rapidity with which water evaporated, it was evident that this wind was in a state of extreme dryness. The Tiber has furnished me with a number of still more striking examples. October 13th, the night having been very clear, on arriving at the Ponte Molle, at half past six in the morning, I found no mist on the river, yet the temperature of the air immediately above it was $48^0$ F., and that of the river $56^0$ F., a strong north wind blew, which indicated, by the hygrometer, a degree of dryness of 55°, and this part of the river was exposed to it; but the valley above, where the river was sheltered from the wind, was full of mist, and the mist in rising to the exposed level might be seen, as it were, dissolving, presenting thin striæ, which never reached above a certain elevation, and many of which disappeared a few seconds after

they rose. From the 13th to the 25th of October, during which time the tramontane or north wind blew, I witnessed repeatedly the same phenomenon, and in the whole of this time, there was only one morning when there was no mist in the sheltered valleys, and the cause was perfectly obvious; the night had been very cloudy, and the thermometer, before sunrise, indicated a difference of only one degree in the atmosphere below that of the river.

It is not my intention to discuss the general subject of the deposition of water from the atmosphere, in this paper; but merely to describe a local cause of considerable extent and variety in its modifications: and which is not without an effect in the economy of Nature, for verdure and fertility, in hot climates, generally follow the courses of rivers, and by the operation of this cause, are extended to the hills, and even to the plains surrounding their banks.

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## Art. XVII.—*Account of* Mr Barton's *Method of making the Iris Metal ornaments, or of ornamenting Steel, and other Metals with Prismatic Colours.* [*Edin. Phil. Jour.*]

The production of the prismatic tints, by scratches upon the surfaces of metallic and transparent bodies, was first observed by the celebrated Boyle. They were particularly studied by Mazeas and Mr Brougham; and Dr Thomas Young afterwards examined them with particular care, and ranked them in the class of optical phenomena, known by the name of the "Colours of striated Surfaces."

Dr Young's experiments were made on the prismatic colours displayed in Mr Coventry's micrometers, consisting of parallel lines drawn upon glass, at the distance of $\frac{1}{500}$th of an inch. Each of these lines he found to consist of two or more finer lines, at the distance of somewhat more than $\frac{1}{20}$th of that of the adjacent lines. Dr Young ascribes these colours to the interference of two portions of light, the one reflected from one side of the groove, and the other portion from the other side; and he concludes, that there is a striking analogy between this separation of colours, and the production of a musical note, by successive echoes from equidistant iron palisades.

This class of colours was afterwards investigated by Dr Brewster, as exhibited in mother-of-pearl, and in various other ways. He found, by the aid of the microscope, that they arose from grooves in its surface; that they were produced when the flat surface was unpolished, and that they could be communicated to wax, gum-arabic, tinfoil, the fusible metal, and even to lead, by hard pressure, or the blow of a hammer. He determined also, that the mottled colours upon all bodies with an imperfect polish, and the scratches or grooves upon polished metals, could be communicated to wax, and other substances.*

The same structure which gives these communicable colours, he succeeded in producing artificially on the surface of calves-feet jelly, that had been boiled for a considerable time. This surface was covered with corrugations, but totally unconnected with these corrugations, he discovered with a powerful microscope, the same minute grooves which exist in mother-of-pearl, and they were so near one another, that some thousands of them must have been contained in a single inch. These grooves were completely invisible to the unassisted eye, but they gave in a very distinct manner, the colours of mother-of-pearl.

Mr Barton, of the mint, a gentleman well known for his ingenuity and his mechanical attainments, has recently conceived the happy idea of ornamenting steel, and other articles, with the colours of striated surfaces, and has secured, by patent, the exclusive privilege of applying this principle to practical purposes. The excellence of Mr Barton's engine has, no doubt, enabled him to execute this kind of work, with a beauty and precision which no other person can hope to imitate. The engine which he uses was given to him by his father-in-law, the late celebrated Mr Harrison. It was constructed by Mr Harrison himself, and its merits depend chiefly on the beauty and correctness of the screw; the apparatus for cutting which, by an excellent inclined plane, also accompanied the engine. The plate in the screw is not divided higher than the 2000dth part of an inch; but Mr Barton has drawn divisions on steel and glass so minute as the

* Dr Brewster also succeeded in communicating the colours from one piece of wax to another piece of wax, and from this second piece to a third piece. By a little precaution, a sunk impression may, upon the same principle, be taken from a wax seal, upon another piece of wax; and this may be used, for a long time, to give impressions nearly as distinct as the original seal. If the piece of wax to be used is hardened with lac, it will last still longer.

10,000dth part of an inch. In drawing lines of 2000 in an inch, Mr Barton often leaves out one line intentionally; and one of the greatest proofs of the stability of the engine is, that after having taken off the brass table, with the work upon it, (when the omission is distinctly perceived,) he can restore it to its place, and introduce the line, without its being distinguishable from the rest.

In applying the principle of striated colours to ornament steel, the effect or pattern is produced upon the polished surface, by the point of a diamond, so that either the whole, or a part of the surface, is covered with lines or grooves, whose distance may vary from the 1000th to the 10,000th of an inch. When these lines are most distant, the prismatic images of the candle, or any luminous body, seen by reflection from the polished surface, are nearest one another and the common colourless image; and when the lines are least distant, the coloured images are farthest from one another, and the colours are most vivid.

In day-light, the colours produced by these minute grooves are scarcely distinguishable, unless at the boundary between a dark and a luminous object; and we conceive that their brilliancy will be very much impaired, even with artificial lights, when they are dispersed by the interposition of globes or hemispheres of ground glass.

In sharp lights, however, and particularly in that of the sun, the colours shine with extraordinary brilliancy, and the play of tints which accompany every luminous image, can only be equalled by their matchless exhibition in the reflections of the diamond. The surface of fine steel, therefore, when grooved by such a skilful hand as Mr Barton's, is peculiarly fitted for imitative jewels, and other articles of female dress; and we have no doubt, that it will find an application to many other purposes, both of use and ornament.

The divisions which Mr Barton most commonly uses for his metal ornaments are 2000 to an inch; but when the material is good, his engine enables him to divide to 5000 and 10,000. When the lines, however, are so close, the labour is very great; but the beauty of the work is generally a compensation for the time bestowed upon it, as the strength of the colours increases with the number of lines. The depth of the line, Mr Barton finds to have great effect in producing brilliancy, owing to the increase in the quantity of reflected light; and he is in some measure, enabled to judge of the depth, by the faintness of the reflected image of his eye,

when looking perpendicularly at the steel; until, at last, by totally removing the original surface, in consequence of the edges of the cut meeting, the whole surface looks black, and the eye is no longer seen.

Since the preceding notice was written, Mr Barton has had the kindness to favour us with various specimens of the ornaments executed by his engine, and high as our expectations were, we confess they were greatly surpassed by the work itself.

Some of the specimens are struck from steel dies, containing the grooved pattern, and it is singular to observe the perfection with which the impress of such delicate work has been conveyed.

In one of the patterns on polished steel, a spiral line, beginning at the centre, advances to the circumference of a circle, about $\frac{3}{4}$ths of an inch in diameter, each coil of the spiral keeping at the distance of about $\frac{1}{930}$th of an inch from the one adjacent to it. When the eye, held close to this specimen, views a lighted candle reflected from the grooved surface, it appears surrounded with a series of the most brilliant concentric rings of coloured light, passing into a sort of tinted radiance of exquisite beauty.

When these minute grooves were drawn by Mr Barton upon rock-crystal, he was surprised, upon taking it from the engine, to perceive no traces whatever of his work. The lines, indeed, are so fine, that it is impossible to discover, even by the aid of a microscope, any roughness or diminution of polish, although its whole surface is covered with grooves, in two directions transverse to each other, and at the distance of the 2000th part of an inch. The moment, however, we expose it to the sun, or the light of a candle, we discover the existence of the grooves, from the faint prismatic images on each side of the candle.

We trust that Mr Barton's ingenuity will be amply rewarded by the public taste; and the only regret we feel is, that he should have taken out his patent, before Mr Wrottesley's bill, or some other enactment, shall have secured to inventors, the just advantage of their labours, and put an end to that fallacious system of nominal privileges, which has ruined so many ingenious and enterprising individuals.

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## Art. XVIII.—*On the Alloys of Steel.* By J. Stodart, Esq. F. R. S., and Mr M. Faraday, Chemical Assistant in the Royal Institution.* [*Lond. Phil. Mag.*]

The alloys of steel made on a small scale in the laboratory of the Royal Institution proving to be good, and the experiments having excited a very considerable degree of interest, both at home and abroad, gave encouragement to attempt the work on a more extended scale; and we have now the pleasure of stating, that alloys similar to those made in the Royal Institution, have been made for the purpose of manufacture; and that they prove to be, in point of excellence, in every respect equal, if not superior, to the smaller productions of the laboratory. Previous, however, to extending the work, the former experiments were carefully repeated, and to the results were added some new combinations, namely, steel with palladium, steel with iridium and osmium, and latterly, steel with chromium. In this last series of experiments we were particularly fortunate, having by practice acquired considerable address in the management of the furnaces, and succeeded in procuring the best fuel for the purpose. Notwithstanding the many advantages met with in the laboratory of the Royal Institution, the experiments were frequently rendered tedious from causes often unexpected, and sometimes difficult to overcome; among these, the failure of crucibles was perhaps the most perplexing. We have never yet found a crucible capable of bearing the high degree of temperature required to produce the perfect reduction of titanium; indeed we are rather disposed to question whether this metal has ever been so reduced: our furnaces are equal† (if any are) to produce this effect, but hitherto we have failed in procuring a crucible.

The metals that form the most valuable alloys with steel are silver, platina, rhodium, iridium and osmium, and palladium; all of these have now been made in the large way, except indeed the last named. Palladium has, for very obvious reasons, been used but sparingly; four pounds of steel with $\frac{1}{100}$ part of palladium, have however been fused at once,

* First published in the Philosophical Transactions.

† We have succeeded in fusing in these furnaces rhodium, and also, though imperfectly, platinum in crucibles.

and the compound is truly valuable, more especially for making instruments that require perfect smoothness of edge.

We are happy to acknowledge the obligations due from us to Dr Wollaston, whose assistance we experienced in every stage of our progress, and by whom we were furnished with all the scarce and valuable metals; and that with a liberality which enabled us to transfer our operations from the laboratory of the chemist, to the furnace of the maker of cast steel.

In making the alloys on a large scale, we were under the necessity of removing our operations from London to a steel furnace at Sheffield; and being prevented by other avocations from giving personal attendance, the superintendence of the work was consequently entrusted to an intelligent and confidential agent. To him the steel, together with the alloying metals in the exact proportion, and in the most favourable state for the purpose, was forwarded, with instructions to see the whole of the metals, and nothing else, packed into the crucible, and placed in the furnace, to attend to it while there, and to suffer it to remain for some considerable time in a state of thin fusion, previous to its being poured out into the mould. The cast ingot was next, under the same superintendence, taken to the tilting mill, where it was forged into bars of a convenient size, at a temperature not higher than just to render the metal sufficiently malleable under the tilt hammer. When returned to us, it was subjected to examination both mechanical and chemical, as well as compared with the similar products of the laboratory. From the external appearance, as well as from the texture of the part when broken by the blow of the hammer, we were able to form a tolerably correct judgment as to its general merits; the hardness, toughness, and other properties, were farther proved by severe trials, after being fashioned into some instrument, or tool, and properly hardened and tempered.

It would prove tedious to enter into a detail of experiments made in the Royal Institution; a brief notice of them will at present be sufficient. After making imitations of various specimens of meteoric iron, by fusing together pure iron and nickel, in proportions of 3 to 10 per cent, we attempted making an alloy of steel with silver, but failed, owing to a superabundance of the latter metal. It was found, after very many trials, that only the $\frac{1}{500}$ part of silver would combine with steel, and when more was used a part of the silver was found in the form of metallic dew, lining the top and sides of the crucible; the fused button itself was a mere mechanical mix-

ture of the two metals, globules of silver being pressed out of the mass by contraction in cooling, and more of these globules being forced out by the hammer in forging; and further, when the forged piece was examined, by dissecting it with diluted sulphuric acid, threads or fibres of silver were seen mixed with the steel, having something of the appearance of steel and platina when united by welding: but when the proportion of silver was only $\frac{1}{500}$ part, neither dew, globules, nor fibres appeared, the metals being in a state of perfect chemical combination, and the silver could only be detected by a delicate chemical test.

With platina and rhodium, steel combines in every proportion; and this appears also to be the case with iridium and osmium: from 1 to 80 per cent of platina was perfectly combined with steel, in buttons of from 500 to 2000 grains. With rhodium, from 1 to 50 per cent was successfully used. Equal parts by weight of steel and rhodium gave a button, which, when polished, exhibited a surface of the most exquisite beauty: the colour of this specimen is the finest imaginable for a metallic mirror, nor does it tarnish by long exposure to the atmosphere: the specific gravity of this beautiful compound is 9.176. The same proportion of steel and platina gave a good button, but a surface highly crystaline renders it altogether unfit for a mirror. In the laboratory we ascertained that, with the exception of silver, the best proportion of the alloying metal, when the object in view was the improvement of edge-tools, was about $\frac{1}{100}$ part, and in this proportion they have been used in the large way. It may be right to notice, that in fusing the metals in the laboratory no flux whatever was used, nor did the use of any ever appear to be required.

Silver being comparatively of little value with some of the alloying metals, we were disposed to make trial with it as the first experiment in the large way. 8lb. of very good Indian steel was sent to our agent, and with it $\frac{1}{500}$ part of pure silver: a part of this was lost owing to a defect in the mould; a sufficient quantity was however saved, to satisfy us as to the success of the experiment. This, when returned, had the most favourable appearance both as to surface and fracture; it was harder than the best cast steel, or even than the Indian wootz, with no disposition whatever to crack, either under the hammer, or in hardening. Some articles, for various uses, have been made from this alloy; they prove to be of a very superior quality. Its application will probably be extended

not only to the manufacture of cutlery, but also to various descriptions of tools; the trifling addition of price cannot operate against its very general introduction. The silver alloy may be advantageously used for almost every purpose for which good steel is required.

Our next experiment made in the large way, was with steel and platina. 10lb. of the same steel, with $\frac{1}{100}$ part of platina, the latter in the state produced by heating the ammonia muriate in a crucible to redness, was forwarded to our agent, with instructions to treat this in the same way as the last-named metals. The whole of this was returned in bars remarkable for smoothness of surface and beauty of fracture. Our own observation, as well as that of the workmen employed to make from it various articles of cutlery, was, that this alloy, though not so hard as the former, had considerably more toughness: this property will render it valuable for every purpose where tenacity, as well as hardness is required; neither will the expense of platina exclude it from a pretty general application in the arts; its excellence will much more than repay the extra cost.

The alloys of steel with rhodium have also been made in the large way, and are perhaps the most valuable of all; but these, however desirable, can never, owing to the scarcity of the metal, be brought into very general use. The compound of steel, iridium and osmium, made in the large way, is also of great value; but the same cause, namely, the scarcity and difficulty of procuring the metals, will operate against its very general introduction. A sufficient quantity of these metals may, perhaps, be obtained to combine with steel for the purpose of making some delicate instruments, and also as an article of luxury, when manufactured into razors. In the mean time, we have been enabled, repeatedly, to make all these alloys (that with palladium excepted) in masses of from 8 to 20lb. each; with such liberality were we furnished with the metals from the source already named.

A point of great importance in experiments of this kind was, to ascertain whether the products obtained were exactly such as we wished to produce. For this purpose, a part of each product was analysed, and in some cases the quantity ascertained; but it was not considered necessary in every case to verify the quantity by analysis, because, in all the experiments made in the laboratory, the button produced after fusion was weighed, and if it fell short of the weight of both metals put into the crucible, it was rejected as imperfect, and

put aside. When the button gave the weight, and on analysis gave proofs of containing the metal put in to form the alloy, and also on being forged into a bar and acted on by acids, presented a uniform surface, we considered the evidence of its composition as sufficiently satisfactory. The processes of analysis, though simple, we shall briefly state: the information may be desirable to others who may be engaged on similar experiments; and, farther, may enable every one to detect any attempt at imposition. It would be very desirable at present, to possess a test as simple, by which we could distinguish the wootz, or steel of India, from that of Europe; but this, unfortunately, requires a much more difficult process of analysis.

To ascertain if platina is in combination with steel, a small portion of the metal, or some filings taken from the bar, is to be put into dilute sulphuric acid; there will be rapid action; the iron will be dissolved, and a black sediment left, which will contain carbon, hydrogen, iron, and platina; the carbon and hydrogen are to be burnt off, the small portion of iron separated by muriatic acid, and the residuum dissolved in a drop or two of nitro-muriatic acid. If a piece of glass be moistened with this solution, and then heated by a spirit-lamp and the blow-pipe, the platina is reduced, and forms a metallic coating on the glass.

In analysing the alloy of steel and silver, it is to be acted on by dilute sulphuric acid, and the powder boiled in the acid; the silver will remain in such a minute state of division, that it will require some time to deposit. The powder is then to be boiled in a small portion of strong muriatic acid*; this will dissolve the iron and silver, and the latter will fall down as a chloride of silver on dilution with water; or the powder may be dissolved in pure nitric acid, and tested by muriatic acid and ammonia.

The alloy of steel and palladium, acted on by dilute sulphuric acid, and boiled in that acid, left a powder, which, when the charcoal was burnt from it, and the iron partly separated by cold muriatic acid, gave on solution in hot muriatic acid, or in nitro-muriatic acid, a muriate of palladium. The solution, when precipitated by prussiate of mercury, gave prussiate of palladium; and a glass plate moistened with

* Although it is a generally received opinion that muriatic acid does not act on silver, yet that is not the case; pure muriatic acid dissolves a small portion of silver very readily.

it and heated to redness, became coated with metallic palladium.

The residuum of the rhodium alloy obtained by boiling in diluted sulphuric acid, had the combustible matter burnt off, and the powder digested in hot muriatic acid: this removed the iron; and by long digestion in nitro-muriatic acid, a muriate of rhodium was formed, distinguishable by its colour, and by the triple salt it formed with muriate of soda.

To analyse the compound of steel with iridium and osmium, the alloy should be acted on by dilute sulphuric acid, and the residuum boiled in the acid; the powder left is to be collected and heated with caustic soda in a silver crucible to dull redness for a quarter of an hour, the whole to be mixed with water, and having had excess of sulphuric acid added, it is to be distilled, and that which passes over condensed in a flask: it will be a solution of oxide of osmium; will have the peculiar smell belonging to that substance, and will give a blue precipitate with tincture of galls. The portion in the retort being then poured out, the insoluble part is to be washed in repeated portions of water, and then being first slightly acted on by muriatic acid to remove the iron, is to be treated with nitro-muriatic acid, which will give a muriate of iridium.

In these analyses, an experienced eye will frequently perceive, on the first action of the acid, the presence of the alloying metal. When this is platina, gold, or silver, a film of the metal is quickly formed on the surface of the acid.

Of alloys of platina, palladium, rhodium, and iridium and osmium, a ready test is offered when the point is not to ascertain what the metal is, but merely whether it be present or not. For this purpose we have only to compare the action of the same acid on the alloy and on a piece of steel; the increased action on the alloy immediately indicates the presence of the metal; and by the difference of action, which on experience is found to be produced with the different metals, a judgment may be formed even of the particular one present.

The order in which the different alloys stand with regard to this action, is as follows: steel, chromium alloy, silver alloy, gold alloy, nickel alloy, rhodium alloy, iridium and osmium alloy, palladium alloy, platina alloy. With similar acid the action on the pure steel was scarcely perceptible; the silver alloy gave very little gas, nor was the gold much acted on. All the others gave gas copiously, but the platina alloy in most abundance.

In connection with the analysis of these alloys, there are some very interesting facts to be observed during the action of acids on them, and perhaps none of these are more striking than those last referred to. When the alloys are immersed in diluted acid, the peculiar properties which some of them exhibit, not only mark and distinguish them from common steel, and from each other, but also give rise to some considerations on the state of particles of matter of different kinds, when in intimate mixture or in combination, which may lead to clearer and more perfect ideas on this subject.

If two pieces, one of steel, and one of steel alloyed with platina, be immersed in weak sulphuric acid, the alloy will be immediately acted on with great rapidity and the evolution of much gas, and will shortly be dissolved, whilst the steel will be scarcely at all affected. In this case, it is hardly possible to compare the strength of the two actions. If the gas be collected from the alloy and from the steel for equal intervals of time, the first portions will surpass the second some hundreds of times.

A very small quantity of platina alloyed with steel confers this property on it: $\frac{1}{400}$ increased the action considerably; with $\frac{1}{200}$ and $\frac{1}{100}$ it was powerful; with 10 per cent of platina it acted, but not with much power; with 50 per cent the action was not more than with steel alone; and an alloy of 90 platina with 20 steel, was not affected by the acid.

The action of other acids on these alloys is similar to that of sulphuric acid, and is such as would be anticipated: dilute muriatic acid, phosphoric acid, and even oxalic acid, acted on the platina alloy with the liberation of more gas than from zinc; and tartaric acid and acetic acid rapidly dissolved it. In this way chalybeate solutions, containing small portions of protoxide of iron, may be readily obtained.

The cause of the increased action of acids on this and similar alloys, is, as the President of this Society suggested to us, probably electrical. It may be considered as occasioned by the alloying metal existing in such a state in the mass, that its particles form voltaic combinations with the particles of steel, either directly or by producing a definite alloy, which is diffused through the rest of the steel; in which case the whole mass would be a series of such voltaic combinations: or it may be occasioned by the liberation, on the first action of the acid, of particles which, if not pure platina, contain, as has been shown, a very large proportion of that metal, and which, being in close contact with the rest of the mass, form voltaic

combinations with it in a very active state: or, in the third place, it may result from the iron being mechanically divided by the platina, so that its particles are more readily attacked by the acid, analogous to the case of proto-sulphuret of iron.

Although we have not been able to prove by such experiments, as may be considered strictly decisive, to which of these causes the action is owing, or how much is due to any of them, yet we do not hesitate to consider the second as almost entirely, if not quite, the one that is active. The reasons which induce us to suppose this to be the true cause of the action, rather than any peculiar and previous arrangement of the particles of steel and platina, or than the state of division of the steel, are, that the two metals combine in every proportion we have tried, and do not, in any case, exhibit evidences of a separation between them, like those, for instance, which steel and silver exhibit; that when, instead of an acid, weaker agents are used, the alloy does not seem to act with them as if it was a series of infinitely minute voltaic combinations of steel and platina, but exactly as steel alone would do; that the mass does not render platina wire more negative than steel, as it probably in the third case would do; that it does not rust more rapidly in a damp atmosphere; and that when placed in saline solutions, as muriate of soda, &c., there is no action takes place between them. In such cases it acts just like steel; and no agent that we have as yet tried, has produced voltaic action that was not first able to set a portion of the platina free by dissolving out the iron.

Other interesting phenomena exhibited by the action of acid on these steels, are the differences produced when they are hard and when soft. Mr Daniel, in his interesting paper on the mechanical structure of iron, published in the Journal of Science, has remarked, that pieces of hard and soft steel being placed in muriatic acid, the first required five-fold the time of the latter to saturate the acid; and that when its surface was examined, it was covered with small cavities like worm-eaten wood, and was compact and not at all striated, and that the latter presented a fibrous and wavy texture.

The properties of the platina alloy have enabled us to observe other differences between hard and soft steel equally striking. When two portions of the platina alloy, one hard and one soft, are put into the same diluted sulphuric acid and suffered to remain for a few hours, then taken out and examined, the hard piece presents a covering of a metallic black carbonaceous powder, and the surface is generally slightly

fibrous: but the soft piece, on examination, is found to be covered with a thick coat of grey metallic plumbaginous matter, soft to the touch, and which may be cut with a knife, and its quantity seven or eight times that of the powder on the hard piece: it does not appear as if it contained any free charcoal, but considerably resembles the plumbaginous powder Mr Daniel describes as obtained by the action of acid on cast iron.

The same difference is observed if pure steel be used, but it is not so striking; because, being much less rapidly attacked by the acid, it has to remain longer in it, and the powder produced is still further acted on.

The powder procured from the soft steel or alloy in these experiments, when it has not remained long in the acid, exactly resembles finely divided plumbago, and appears to be a carburet of iron, and probably of the alloying metal also. It is not acted on by water, but in the air the iron oxidates and discolours the substance. When it remains long in the acid, or is boiled in it, it is reduced to the same state as the powder from the hard steel or alloy.

When any of these residua are boiled in diluted sulphuric or muriatic acid, protoxide of iron is dissolved, and a black powder remains unalterable by the further action of the acid; it is apparently in greater quantity from the alloys than from pure steel, and when washed, dried, and heated to 300° or 400° in the air, burns like pyrophorus, with much fume: or if lighted, burns like bitumen, and with a bright flame; the residuum is protoxide of iron, and the alloying metal. Hence, during the action of the acid on the steel, a portion of hydrogen enters into combination with part of the metal and the charcoal, and forms an inflammable compound not acted upon by the acid.

Some striking effects are produced by the action of nitric acid on these powders. If that from pure steel be taken, it is entirely dissolved; and such is also the case if the powder be taken from an alloy, the metal of which is soluble in nitric acid; but if the powder is from an alloy, the metal of which is not soluble in nitric acid, then a black residuum is left not touched by the acid; and which, when washed and carefully dried, is found, when heated, to be deflagrating; and with some of the metals, when carefully prepared, strongly explosive.

The fulminating preparation obtained from the platina alloy, when dissolved in nitro-muriatic acid, gave a solution

containing much platina, and very little iron. When a little of it was wrapped in foil and heated, it exploded with much force, tearing open the foil, and evolving a faint light. When dropped on the surface of heated mercury, it exploded readily at 400° of Fahrenheit, but with difficulty at 370°. When its temperature was raised slowly, it did not explode, but was decomposed quietly. When detonated in the bottom of a hot glass tube, much water and fume were given off, and the residuum collected was metallic platina with a very little iron and charcoal. We are uncertain how far this preparation resembles the fulminating platina of Mr Edmund Davy.

In these alloys of steel the differences of specific gravity are not great, and may probably be in part referred to the denser state of the metals from more or less hammering: at the same time it may be observed, that they are nearly in the order of the specific gravities of the respective alloying metals.

The alloys of steel with gold, tin, copper, and chromium, we have not attempted in the large way. In the laboratory, steel and gold were combined in various proportions;—none of the results were so promising as the alloys already named, nor did either tin or copper, as far as we could judge, at all improve steel. With titanium we failed, owing to the imperfection of crucibles. In one instance, in which the fused button gave a fine damask surface, we were disposed to attribute the appearance to the presence of titanium; but in this we were mistaken;—the fact was, we had unintentionally made wootz. The button, by analysis, gave a little silex and alumine, but not an atom of titanium; menachanite, in a particular state of preparation, was used: this might possibly contain the earths or their basis, or they may have formed a part of the crucible.

M. Berthier, who first made the alloy of steel and chromium,* speaks very favourably of it. We have made only two experiments. 1600 grains of steel, with 16 of pure chrome, were packed into one of the best crucibles, and placed in an excellent blast furnace: the metals were fused, and kept in that state for some time. The fused button proved good and forged well: although hard, it showed no disposition to crack. The surface being brightened, and slightly acted on by dilute sulphuric acid, exhibited a crystalline

* Annales de Chimie, xvii. 55.

appearance; the crystals, being elongated by forging, and the surface again polished, gave, by dilute acid, a very beautiful damask. Again, 1600 grains of steel with 48 of pure chrome were fused: this gave a button considerably harder than the former. This too was as malleable as pure iron, and also gave a very fine damask. Here a phenomenon rather curious was observed: the damask was removed by polishing, and restored by heat without the use of any acid. The damasked surface, now coloured by oxidation, had a very novel appearance: the beauty was heightened by heating the metal in a way to exhibit all the colours caused by oxidation, from pale straw to blue, or from about 430° to 600° of Fahrenheit. The blade of a sabre, or some such instrument, made from this alloy, and treated in this way, would assuredly be beautiful, whatever its other properties might be; for of the value of the chrome alloy for edge tools we are not prepared to speak, not having made trial of its cutting powers. The sabre blade, thus coloured, would amount to a proof of its being well tempered; the blue black would indicate the temper of a watch spring, while the straw colour towards the edge would announce the requisite degree of hardness. It is confessed, that the operation of tempering any blade of considerable length in this way, would be attended with some difficulty.

In the account now given of the different alloys, only one triple compound is noticed, namely, steel, iridium and osmium; but this part of the subject certainly merits further investigation, offering a wide and interesting field of research. Some attempts to form other combinations of this description proved encouraging, but we were prevented, at the time, by various other avocations, from bestowing on them that attention and labour they seemed so well to deserve*.

It is a curious fact, that when pure iron is substituted for steel, the alloys so formed are much less subject to oxidation. 3 per cent of iridium and osmium fused with some pure iron, gave a button, which when forged and polished was exposed, with many other pieces of iron, steel, and alloys, to a moist atmosphere: it was the last of all showing any rust. The colour of this compound was distinctly blue; it had the property of becoming harder when heated to redness, and quenched in a cold fluid. On observing this steel-like character, we suspected the presence of carbon: none, however, was found, although carefully looked for. It is not improbable that there

* It is our intention to continue these experiments at every opportunity; but they are laborious, and require much time and patience.

may be other bodies, besides charcoal, capable of giving to iron the properties of steel; and though we cannot agree with M. Boussingault,* when he would replace carbon in steel by silica or its base, we think his experiments very interesting on this point, which is worthy further examination.

We are not informed as to what extent these alloys, or any of them, have been made at home, or to what uses they have been applied; their more general introduction in the manufacture of cutlery would assuredly add to the value, and consequently to the extension of that branch of trade. There are various other important uses to which the alloys of steel may advantageously be applied. If our information be correct, the alloy of silver, as well as that of platina, has been to some considerable extent in use at His Majesty's Mint. We do know, that several of the alloys have been diligently and successfully made on the continent, very good specimens of some of them having been handed to us; and we are proud of these testimonies of the utility of our endeavours.

To succeed in making and extending the application of these new compounds, a considerable degree of faithful and diligent attention will be required on the part of the operators. The purity of the metals intended to form the compound is essential; the perfect and complete fusion of both must, in every case, be ascertained: it is further requisite, that the metals be kept for some considerable time in the state of thin fusion: after casting, the forging is with equal care to be attended to; the metal must on no account be overheated; and this is more particularly to be attended to when the alloying metal is fusible at a low temperature, as silver. The same care is to be observed in hardening: the article is to be brought to a cherry-red colour, and then instantly quenched in the cold fluid.

In tempering, which is best performed in a metallic bath properly constructed, the bath will require to be heated for the respective alloys, from about 70° to 100° of Fahrenheit above the point of temperature required for the best cast steel. We would further recommend, that this act of tempering be performed twice; that is, at the usual time before grinding, and again just before the last polish is given to the blade. This second tempering may perhaps appear superfluous, but upon trial its utility will be readily admitted. We were led to adopt the practice by analogy, when considering the process of making and tempering watch-springs.

* Annales de Chimie, xvi. 1.

## ART. XIX.—*On a new Species of Rhinoceros found in the Interior of Africa, the Skull of which bears a close resemblance to that found in a fossil state in Siberia, and other Countries.* By Sir EVERARD HOME, Bart. V.P.R.S. [*Phil. Trans.*]

THE discovery of a new species of any of the larger animals, now that our globe has been so extensively explored, is an object of interest to the naturalist, and might afford sufficient reason for laying this new fact before the society; but this interest will be much increased, when there is a striking resemblance between the form and appearance of the skull of this animal, now in being, and the skull of one of the same tribe, only met with in a fossil state.

It has been hitherto asserted, as one of the most curious circumstances in the history of the earth, that all the bones that are found in a fossil state, differ from those belonging to animals now in existence; and I believe that this is generally admitted, and that there is no fact upon record, by which it has been absolutely contradicted; but the observations I am about to state respecting this rhinoceros, will go a great way to stagger our belief upon this subject.

The skull of the animal belonging to this new species of rhinoceros, now living in Africa, was brought to this country by Mr Campbell, one of the missionaries sent there from the London Missionary Society, and is deposited in their museum in the Old Jewry. The following account is taken from the memoranda with which Mr Campbell very obligingly furnished me.

"The animal was shot about 250 or 300 miles, up from the westward of De la Goa Bay, six miles west of the city Mashow, and above a thousand miles in nearly a straight direction from the Cape of Good Hope.

"The country from whence the rhinoceros comes, contains no thick woods, or forests, but is covered with separate clumps of trees, like a nobleman's park in England. In travelling, you always appear to be approaching a wood; but as you advance, the trees are discovered to stand at a distance from one another, or rather in little clumps.

"This animal feeds upon grass, and bushes; is not carnivorous; and not gregarious; seldom more than a pair are seen together, or in the vicinity of one another." Mr Campbell's people wounded another of the same description. "When

enraged it runs in a direct line, ploughing the ground with its horn. The hide is not welted, is of a dark brown colour, smooth, and without hair."

The skull which Mr Campbell has brought to England, fortunately has the horns in their natural situation. The skull is thirty-six inches long. The long horn, thirty-six inches; the circumference at the base, is twenty-four inches. There are horns of different lengths in the British museum, and one forty-two inches.

In this skull it will be seen, that the horns differ in many particulars, from those belonging to the other recent species of the rhinoceros. The long one is placed upon the extremity of the nasal bones, with a direction nearly straight forward, and the smaller one so close behind it, as to appear intended for a support to its base. These striking differences would be of little importance, were it not that they make it bear so close a resemblance to the fossil skull from Siberia, as to leave no prominent characteristic mark between them; and were it not that the one is in a fossil state, and the other recent, they would be decided to belong to the same species; for although there is no horn attached to the fossil skull, the surface fitted for it is obviously marked, and no error can be committed respecting its situation, or direction. The fossil skull was sent over by the emperor of Russia to Sir Joseph Banks, and deposited in the British museum, and compared with another, which came to this country, but was afterwards sent to France. The skull is thirty-three inches long. The largest of the recent rhinoceros in the collection of the Royal College of Surgeons, is two feet.

All the fossil skulls that have been examined, are alike, and three feet long; so that we have now acquired a nearer approach to the form of the skull of the rhinoceros of former ages, in that which is here described, than has before been obtained. From this fact so completely within my own observation, I am led to believe, that although many animals belonging to former ages may be extinct, they are not necessarily so; no change having taken place in our globe, which had destroyed all existing animals, and therefore many of them may be actually in being, although we have not been able to discover them.

When we consider that the course of one of the greatest rivers in Africa, the Niger, has not been traced to its source by any European traveller, we must allow, that great tracts of country in that immense continent remain unexplored; in

which those animals, that are not disposed by their nature to submit to the will of man, but, on the contrary, to fly from him, may conceal themselves by retiring into the wild fastnesses of forests, which for ages to come may never be visited by rational beings. Under these circumstances, we have no right to assume that large animals, although not met with, do not exist.

The following account of the migration of the animals in Africa, is in itself a curious document, and explains in what way particular animals may elude our inquiry at one time, and at another be brought within our reach.

Mr Campbell says, he found that the wild ass, or quagga, migrates in winter from the tropics, to the vicinity of the Malaleveen river, which, though farther to the south, is reported to be warmer than within the tropic of Capricorn, when the sun has retired to the northern hemisphere. He saw bands of two or three hundred, all travelling south, when on his return from the vicinity of the tropics; and various Bushmen, as he proceeded south, inquired if the quaggas were coming. Their stay lasts from two to three months, which in that part of Africa is called the Bushmen's harvest. The lions who follow them are the chief butchers. During that season, the first thing a Bushman does on awaking, is to look to the heavens to discover vultures hovering at an immense height; under any of them he is sure to find a quagga that had been slain by a lion in the night.

This disposition for migration on large continents, will explain their dispersion into different countries.

It is deserving of remark that the elephant, one of the most powerful and most sagacious of the animal race, has been for ages domesticated, (if the expression is admissible,) and has learned to have a pride in the ornaments and trappings, with which man, for the purpose of pomp and parade, has clothed him. It would appear that the sagacity of this noble animal had taught him, that to live in the bondage and society of men, is better than savage liberty; for when he has returned to a wild state, and remained in it for years, upon meeting with his former guide, immediately on hearing his voice he has returned to his duty. On the other hand, the rhinoceros, although an inhabitant of nearly the same countries, varying equally in species, and met with by men of different nations, in the same degree of frequency, has never been brought to a civilized state; but is at this day so savage and stupid in its nature, that it cannot be tamed.

The elephant, we know from observation, as well as from the size of its brain, particularly the cerebrum, has intellect and memory; but in the rhinoceros, so small is the cavity of the cranium, that in all these respects it must be much inferior to the elephant. The capacity of the cavity of the skull of the male rhinoceros from Sumatra, two feet long, is to that of the elephant, as thirty-five ounces to one hundred and eighty-two. The length of the skull of the recent rhinoceros, brought over by Mr Campbell, is three feet; and the cavity, although mutilated, shows it not to be larger than the other. In Mr Brook's skeleton of the rhinoceros, five feet six inches high, the skull is only one foot eleven inches. His skeleton of the elephant is six feet six inches; so that Mr Campbell's rhinoceros must have been of the full size.

The skull of the horse has a capacity which, when compared with that of the rhinoceros, is to the small female of that species, nearly equal.

Skulls of the different species of rhinoceros known to exist, are preserved in the anatomical collections in this country, as well as in France. One species from Sumatra with two horns, one from Africa with two horns, and one with a single horn.

Of all these different species none have been found to possess a common share of intellect; the size of the cavity of the skull in all of them, is nearly the same; and there is no account upon record, of a rhinoceros ever having been tamed, although curiosity alone, would have been a sufficient inducement to have made the attempt, had there been any probability of success.

The following account of the manners and habits of the Asiatic rhinoceros, clothed in armour, and having the welted hide, I have taken from the young man who was its keeper for three years in the Menagerie at Exeter Change, at the end of which period it died.

It was so savage, that about a month after it came to Exeter Change, it endeavoured to kill the keeper, and nearly succeeded. It ran at him with the greatest impetuosity; but fortunately the horn passed between his thighs, and threw the keeper on its head: the horn came against a wooden partition, into which the animal had forced it to such a depth, as to be unable for a minute to withdraw it, and during this interval the man escaped.

Its skin, although apparently so hard, is only covered with small scales of the thickness of paper, with the appearance of

tortoise shell; at the edges of these, the skin itself is exceedingly sensible, either to the bite of a fly, or the lash of a whip; and the only mode of managing it at all was by means of a short whip. By this discipline the keeper got the management of it, and the animal was brought to know him; but frequently, more especially in the middle of the night, fits of phrenzy came on, and while these lasted, nothing could control its rage, the rhinoceros running with great swiftness round the den, playing all kinds of antics, making hideous noises, knocking every thing to pieces, disturbing the whole neighbourhood, then all at once becoming quiet. While the fit was on, even the keeper durst not make his approach. The animal fell upon its knees to enable the horn to bear upon any object. It was quick in all its motions: ate ravenously all kinds of vegetables: appearing to have no selection. They fed it on branches of the willow. It possessed little or no memory; dunged in one place, and if not prevented ate the dung, or spread it over the sides of the wall. Three years confinement made no alteration in its habits.

The account in the Bible of an unicorn not to be tamed, mentioned by Job, bears so great an affinity to this animal, that there is much reason to believe that it is the same, more especially, as no other animal has ever been described so devoid of intellect. In that age, the short horn might readily be overlooked, as it cannot be considered as an offensive weapon; and the smoothness of the animal's skin would give it a greater resemblance to the horse than to any other animal.

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Art. XX.—*Some Experiments and Researches on the Saline Contents of Sea-Water, undertaken with a view to correct and improve its Chemical Analysis.* By Alexander Marcet, M.D., F.R.S., Honorary Professor of Chemistry at Geneva. [*Phil. Trans.*]

In a paper on the temperature and saltness of various seas, which the Royal Society did me the honour to publish in their Transactions for the year 1819, I threw out a conjecture, that the sea might contain minute quantities of every substance in nature, which is soluble in water. For the ocean having communication with every part of the earth through the rivers,

all of which ultimately pour their waters into it; and soluble substances, even such as are theoretically incompatible with each other, being almost in every instance capable of co-existing in solution, provided the quantities be very minute, I could see no reason why the ocean should not be a general receptacle of all bodies which can be held in solution. And although it will appear from the following account, that I have been unsuccessful in some of my attempts to prove the truth of this conjecture, it may fairly be ascribed either to a want of sufficient accuracy in our present methods of chemical analysis, or of the requisite degree of skill in the operator.

Some time after the communication to which I have just referred, an extraordinary statement was pointed out to me, upon the authority of Rouelle, a French chemist of the last century, from which it appeared that mercury was contained in sea salt*: and I saw soon after in the 'Annales du Musée,' vol. vii. a paper by the celebrated chemist Proust, who, in a great measure, confirmed that statement, by announcing that he had found traces of mercury in all the specimens of marine acid which he had examined.

Improbable as the fact appeared, I thought it worth while to repeat the experiment, and to take that opportunity of making some collateral researches upon other substances, much more likely than mercury to be discovered in sea-water.

For this purpose I availed myself of the kindness of my friend Mr John Barry†, who happened to be in the vicinity of Portsmouth, to supply me with specimens of sea-water, carefully concentrated upon the spot, in vessels of Wedgwood ware, and with scrupulous attention to cleanliness in the process. Accordingly he was so obliging, as not only to send me a quantity of brine evaporated under his own eye, in the manner just mentioned, but he also collected for me a valuable series of specimens from the salt-works near Portsmouth, from all the stages of the process, so as to afford me an opportunity of investigating with accuracy all the chemical circumstances of this interesting branch of national economy. Finding myself, however, much pressed by time at this late period of the session, I shall, after briefly adverting to Rouelle's supposed discovery, confine myself in this communication to a few ob-

* See Journal de Médecine, vol. xlviii. 1777, page 322.

† Mr John Barry, of Plough Court, inventor of a new and valuable process for preparing extracts *in vacuo*, &c.

servations which I have made on sea-water itself; keeping out of view, for the present, the topic of salt-making, which, however, I intend to resume at some future period, in a more complete and satisfactory manner.

I first attempted to detect mercury in a specimen of bay-salt, such as is obtained in the salt-works near Portsmouth, by spontaneous evaporation. This variety of salt forms large crystals, but is always more or less contaminated by earthy matter, which gives it a dirty appearance. It has, probably, a general resemblance to the French Sel de Gabelle, which is more impure still, though, I believe, obtained in a similar manner*.

Eight ounces of this salt were put into a coated retort connected with a receiver, and about four ounces of nitrous acid were poured upon it. A pretty brisk action took place, which was further increased by the application of heat; fumes of chlorine were immediately disengaged, and a reddish fluid condensed in the receiver; the heat was continued, and gradually raised in a charcoal fire till no acid or moisture any longer came over; at which time a new emission of red fumes indicated that the nitrate formed in the retort was beginning to part with its acid: minute drops of fused salt soon bedewed the upper part and neck of the retort, so as to be mistaken, at first, for a sublimate. This, however, proved to be almost solely muriate of soda; and on careful examination, it did not appear to contain the smallest atom of corrosive sublimate.

I next dissolved five or six pounds of bay-salt in water, and collected in a filter the insoluble earthy sediment, in which Rouelle stated that the quicksilver was usually found. This sediment being carefully dried, and heated to redness in a coated retort, a white sublimate arose, and condensed on the neck of the retort; but this sublimate proved to be muriate of ammonia, and did not contain the smallest portion of corrosive sublimate or other mercurial salt. This sal-ammoniac, though evidently formed during the distillation from the vegetable and animal matter contained in the sediment, suggested to me the idea of looking for ammonia amongst the contents of sea-water.

I now submitted some Sel de Gabelle, which I had procured from Calais for the purpose, to similar experiments, and

* The name of bay-salt is often applied to foreign as well as British salt, and in general it simply denotes that the salt has been obtained by spontaneous evaporation.

the sediment, also was carefully examined. The result was essentially the same as with the bay-salt. After adding nitric acid to the salt, the heat was gradually pushed to redness; and when all the moisture was evaporated, a white sublimate appeared, as in the former case, which, in this instance, proved to consist almost entirely of nitrate of soda; but always without the least particle of mercurial salt, and without any muriate of ammonia*.

I therefore think myself justified in concluding that the mercury, which other chemists have detected in sea-salt or its products, must have been introduced there from some local or accidental circumstances.

In experiments upon sea-salt, or in general upon the saline contents of the sea, it is obvious that, in order to exclude sources of error, it is necessary to operate upon pure sea-water, and not upon salts obtained from it by the usual processes in the large way, these being always more or less contaminated by the clay pits in which the evaporation is carried on, by the metallic boilers, or other adventitious causes. I therefore now turned my attention to the sea-water itself, and in particular the perfectly pure and transparent specimen of concentrated brine from the channel, which I have above mentioned. Mr Barry procured this water near Bembridge floating light, about two miles N.E. of the eastern extremity of the Isle of Wight, and the evaporation which it had undergone at Portsmouth had only separated from it a quantity of calcareous matter, principally selenite†.

A few pounds of this water were evaporated nearly to dryness, at a gentle heat, so as to reduce the mother liquor to the smallest possible quantity. This liquor was suffered to drain off, and reserved for experiments, as it is in this fluid that any new ingredients are most likely to be detected.

I had suspected that some nitric salt might be found in sea-water; but in this I was disappointed. The discrimination

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* In the former experiment the sublimate was principally muriate of soda, owing, no doubt, to the decomposition having been less complete, and the operation less gradually conducted than in the latter experiment.

† The water, immediately on being raised from the sea, had been allowed to stand a sufficient time to deposit the earthy particles suspended in it, by which means it had become beautifully transparent. 100 pounds of the water produced only three grains of earthy sediment, in which I could discover nothing but carbonate of lime and oxide of iron. It is in this sediment, according to Rouelle, that mercury is to be found. I need hardly say that I could not detect in it the least particle of that metal.

by the shape of the crystals being in this instance scarcely practicable, the mode which I employed for detecting it, consisted in concentrating the bittern in a glass tube or retort, till it began to deposit solid matter, then adding sulphuric acid and gold-leaf, and boiling the mixture; the gold-leaf was not in the least acted upon, nor was any smell of nitric acid perceived; but on adding the smallest quantity of nitre to the same mixture, the gold was dissolved, and the smell of aqua regia was instantly perceived*.

A portion of the said bittern was next examined by appropriate re-agents with a view to detect any minute quantity of earths or metals, especially alumina, silica, iron and copper, which former inquirers might have overlooked; but I could find no other earth except magnesia: and to my surprise, I did not find in the bittern the least particle of lime; which proves that sea-water contains no muriate of lime, as had been generally supposed. I was equally unsuccessful in my attempts to detect iron or copper, by the most delicate tests. In fact, neither alkalies, nor alkaline carbonates, precipitated any other substance from the bittern of sea-water, except magnesia.

The deposit obtained at Portsmouth during the early period of the concentration of the water, being analysed, I found it to consist of selenite, mixed with a little muriate of soda, and a portion of carbonate of lime. The presence of this last substance in sea-water, in a state of perfect solution, being, I believe, a new fact, I neglected no means of establishing it with certainty, an object which was accomplished without difficulty†.

Carbonate of magnesia having been supposed by some chemists to exist in sea-water, I looked for it in the same deposit; but I could not detect the least portion of it by the most delicate tests‡.

I next turned my attention to the alkaline salts of sea-water: and here I was more fortunate; as I succeeded in ascertaining beyond a doubt, that sea-water contains ammonia, as it

* For this easy and elegant process for detecting nitric acid, a point attended with difficulty, I am indebted to Dr Wollaston.

† The deposit was treated with acetic acid, which occasioned an effervescence. The clear liquor being then decanted off, and evaporated to dryness, and alcohol added, acetate of lime was found in the filtered alcoholic liquor.

‡ Namely, solution of the mass in dilute muriatic acid; precipitation of the lime, and addition of phosphate of ammonia to the filtered liquor.

yielded sal-ammoniac by evaporation and sublimation. This result was easily obtained. Some of the bittern being evaporated to dryness in a retort, and a low red heat applied, a white sublimate appeared in the neck of the retort, which proved to be muriate of ammonia. The mode in which this substance was identified was as follows:

1. The sublimate was re-dissolved in water, re-evaporated to dryness, and again sublimed by the heat of a spirit-lamp.

2. This new sublimate being again dissolved, and solution of magnesia and phosphoric acid added, a triple phosphate was formed.

3. On adding caustic potash to the solution, and bringing the mouth of a phial containing muriatic acid close to the vessel, abundant white fumes appeared.

4. The sublimate gave precipitates both with muriate of platina and nitrate of silver*.

Sulphate of soda having been mentioned by many chemists, as one of the constituents of sea-water, I endeavoured to ascertain, whether or not it existed in it. But all attempts to detect this salt in the bittern by crystallization were fruitless, though great pains were taken for that purpose; and I feel the more confident that there is no sulphate of soda in sea-water, as the presence of this salt, in any but the most minute quantities, would be quite incompatible with our knowledge of chemical affinities. For since there are, coexisting in sea-water, muriate of soda and sulphate of magnesia, it is evident that sulphate of soda would decompose muriate of magnesia, which salt is known to be in sea-water. And again we know, that sea-water contains sulphate of lime and muriate of soda; therefore it cannot contain sulphate of soda; for in that case we should have muriate of lime, which I have shown to be contrary to fact.

The last circumstance which I shall at present notice, relates to the state in which potash exists in sea-water†. Potash is

* As it did not enter into my plan, on this occasion, to turn my attention to the estimation of proportions or precise quantities, I have not attempted to estimate exactly the proportion which ammonia bears to the other ingredients of sea-water; but as its presence can easily be shown in 100 grains of the bitter salts, its quantity cannot be extremely minute.

† It will be recollected, that the presence of potash in sea-water, though announced by myself in the paper on sea-water to which I have before alluded, was Dr Wollaston's discovery. I have likewise to mention, that the above experiments respecting the state in which it exists, were either made by him or at his suggestion.

found, by its appropriate re-agents, principally in the bittern; but it is found also among the salts which are separated from it, especially in the later period of crystallization. By further and repeated evaporation of the bittern, and successive separation of the mother-water remaining after the removal of the crystals formed, various distinct crystals were obtained possessing their characteristic form, namely, prismatic sulphate of magnesia, cubic and star-shaped muriate of soda, and rhombic crystals, quite different from either of the other salts. These crystals, which were evidently portions of an oblique rhombic prism, being carefully separated and washed with water and alcohol, proved to be a triple salt of sulphate of potash and magnesia; a salt so easily analysed, that it would be quite superfluous to relate the particulars of the process.

It now remained to be ascertained, whether potash might not also exist in sea-water in the state of muriate of potash, or of triple muriate of potash and magnesia. That a considerable quantity of potash remains in the bittern, even after the separation of the triple sulphate, is easily ascertained; and by careful evaporation it may be made to crystallize as a triple salt in rhombic crystals; but the constitution of this salt is so delicate, that it is liable to be separated into muriate of potash and muriate of magnesia by water alone; and it is with certainty decomposed by alcohol, which takes up the magnesian muriate, and leaves the other undissolved.

From the foregoing observations and experiments it may, therefore, be inferred,

1st. That there is no mercury, or mercurial salt, in the waters of the ocean.

2dly. That sea-water contains no nitrates.

3dly. That it contains sal-ammoniac.

4thly. That it holds carbonate of lime in solution.

5thly. That it contains no muriate of lime.

6thly. That it contains a triple sulphate of magnesia and potash.

Some of these circumstances will, of course, require that former analyses of sea-water, and my own in particular, should be corrected and revised; but this I shall not attempt to do, until I have obtained further and still more precise information on the subject.

ART. XXI.—*On Animals receiving their Nutriment from Mineral Substance.* By the Rev. W. KIRBY, M. A., F. R. S., F. L. S. [*Phil. Mag.*]

MIRBEL has proposed to distinguish vegetables from animals by the different nature of their food: the former deriving their nutriment, as he affirms, from inorganic matter, and the latter from organic. Another able and learned physiologist, Dr Virey, in the Nouveau Dictionnaire d'Histoire Naturelle, article *Aliment*, maintains, on the contrary, that plants as well as animals are supported by organic food; since, as he contends, it is the debris of organized matter, mixed with the soil, that furnishes plants with their appropriate pabulum, as likewise those animals, such as earthworms, the larvæ of ephemeræ, &c. which have been supposed to live upon earth. He also excludes water and air from the function in question. The arguments which he adduces in support of his hypothesis appear ingenious and forcible: the principal one is, that the fertility of a soil depends upon the quantity of humus or vegetable earth that it contains; and that worms, &c. are not to be found in very barren soils. Still, however, there is no general rule without some exceptions: and one has fallen under my own notice, which seems to prove that there are animals that can derive nutriment from a mineral substance, in which there are no debris of organized matter. When I was lately in town, Mr Hunneman, of Queen-street, Soho, informed me that he had received some specimens of asbestos from Professor Bonelli, which upon examination were found to contain many larvæ of some insect, that had perforated it in various directions, and in it underwent their customary metamorphoses. These, when arrived at their perfect state, proved to be a species of beetle of the genus dermestes—a tribe that usually feeds upon dead animal matter when dried. He obligingly gave me specimens of the beetles, and also of the asbestos; the latter appeared to be of the flexible kind, which is called amianth. Upon examining the former, I find it to be the dermestes vulpinus Fabr. (Oliv. Ins. No. 9. t. i. f. 6,) a species common to South Europe and South Africa. As the animals of this tribe are not particular in selecting a place in which to undergo their metamorphosis, it is not probable that they would have taken the trouble to perforate the asbestos for that sole purpose, since they will not only assume the pupa in the exuviæ of the animal they have devoured, but

even under their own excrement: (see De Geer, iv. 196 :) but a further proof that this was not their object, is furnished by the varying size of the holes perforated in the specimen of the amianth that Mr Hunneman gave me. There were three, one of which was a line and a half in diameter; another, a line and three fourths; and a third, two lines: from whence it seems to follow that the insects that perforated it were in different stages of growth; and consequently derived nutriment from that substance.

I hope that the fact I have here recorded will not be unworthy a place in the Philosophical Magazine, and that it may stimulate some of your readers, who may have had an opportunity of making observations on similar subjects, to lay them before the public. Insulated facts, though seemingly trifling, are often of great use to the physiologist and natural philosopher.

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## Art. XXII.—*Observations on the Orang Outang.*

The third volume of the Memoirs of the Wernerian Society of Edinburgh contains an elaborate paper by Dr Thomas Stewart Traill, of Liverpool, on the anatomy of the Orang Outang. As it appears that most, if not all the engravings and delineations of this animal in works on natural history, are extremely incorrect, we have prepared the following account of some parts of this highly interesting paper. [J. W. W.]

The animal in question was a female, and was brought from the Isle of Princes, in the gulf of Guinea, where it had been carried by a native trader from the banks of the Gaboon. When erect it was about thirty inches high, and was said to be young, being inferior in size to many seen in its native forests. The natives of Gaboon assert that this species attains the height of five or six feet; that it is a formidable antagonist to the elephant, and that several of them will not scruple to attack the lion, and other beasts of prey, with clubs and stones. It attacks solitary travellers, and is said to carry off negro girls, some of whom after a captivity of a number of years, have made their escape, and returned to human society. Dr Traill remarks that these reports confirm the narratives of the early voyagers, Purchas, Dampier, Battel, and others, and that similar facts have been recently stated, very circumstantially, by gentlemen who have lived in Western Africa.

The negroes believe the animal to have rational powers, and the faculty of speaking, of which it cunningly avoids the exercise through fear of being compelled to labour.

Captain Payne, by whom the animal examined by Dr Traill, was brought to England, says, when it first came on board, it shook hands with some of the sailors, but refused its hand, with marks of anger, to others, without any apparent cause. It speedily, however, became familiar with the crew, except one boy, to whom it never was reconciled. When the seamen's mess was brought on deck, it was a constant attendant; would go round and embrace each person, while it uttered loud yells, and then seat itself among them to share the repast. When angry, it sometimes made a barking noise like a dog; at other times it would cry like a pettish child, and scratch itself with great vehemence. It expressed satisfaction, especially on receiving sweetmeats, by a sound like *hem*, in a grave tone; but it seemed to have little variety in its voice. In warm latitudes, it was active and cheerful, but became languid as it receded from the torrid zone; and on approaching the shores of England it shewed a desire to have a warm covering, and would roll itself carefully up in a blanket when it retired to rest. It generally walked on all fours; and captain Payne particularly remarked that it never placed the palm of the hands of its fore extremities to the ground, but, closing its fists, rested on the knuckles; a circumstance also noticed by Tyson, which was confirmed to Dr Traill by a young naval officer, who had been for a considerable time employed in the rivers of Western Africa, and had opportunities of observing the habits of this species. The animal did not seem fond of the erect posture, which it rarely affected, though it could run nimbly on two feet for a short distance. In this case, it appeared to aid the motion of its legs, by grasping the thighs with its hands. It had great strength in the four fingers of its superior extremity; for it would often swing by them on a rope upwards of an hour, without intermission. When first procured, it was so thickly covered with hair, that the skin of the trunk and limbs was scarcely visible, until the long black hair was blown aside. At that period, the skin was free from any disease: but after it had been some time at sea, much of its hair fell off, its body was attacked by a scaly eruption, resembling *psoriasis guttata* and attended by excessive itching. This, Dr Traill thinks, may have been owing to improper food. It ate readily every sort of vegetable food; but at first did not appear to relish flesh,

though it seemed to take pleasure in sucking the leg-bone of a fowl. It acquired a relish for wine, but not for ardent spirits. It once stole a bottle of wine, which it uncorked with its teeth, and began to drink. It was immoderately fond of sweet articles of food; it learned to feed itself with a spoon, to drink out of a glass, and shewed a general disposition to imitate the actions of men. It was attracted by bright metals, seemed to take pride in clothing, and often put a cocked hat on its head. It was dirty in its habits, and was never known to wash itself. It was afraid of fire arms; and on the whole appeared a timid animal. It lived with captain Payne seventeen weeks.

The skin of the animal was of a yellowish white, thinly covered with long black hair on the front; but more hairy behind. The hair on the head was thinner than on the forehead, and in front of the ears formed whiskers. The principal part of the face was naked, and the skin whitish and wrinkled. The longest hair was at the elbows.

The ears were remarkably prominent, in shape somewhat resembling the human. The nose was quite flat, and appeared only as a wrinkle of the skin, with a slight depression along its centre. The nostrils were patulous and open upwards, which would be inconvenient did the animal usually assume the erect posture. The projection of the jaws was excessive; but less so than in the baboon. Dr Traill remarks that the projection of the lower jaw, as represented in the first and second figures of Camper's second plate, is caricatured. The mouth was wide, and the lips thin, being destitute of that recurvation of the edges which adds so much to the expression of the human countenance. The whole contour of the head bore no inconsiderable resemblance to some Egyptian figures of the god Anubis.

With regard to the limbs, observes Dr Traill, the chief difference between our specimen and Dr Tyson's figure, consists in the excessive length of the arms; which in this animal, descend below the knees, by the whole length of the phalanges of the fingers, which are above three inches in length. The proportions in the work of Camper, approach nearest to the present instance in this particular. The hand differs from the human, in having the thumb by far the smallest of the fingers. The foot is more properly a hand appended to a tarsus. The thumb of this extremity is very long, powerful, and capable of great extension.

Dr Traill describes the peculiarities of the internal structure of the orang outang with great minuteness. He remarks that the general appearance of the skeleton is pretty accurately given by Dr Tyson. The general form of the head approaches nearer to that of man, than in any other species of this genus; but the top of the head is rather flatter, and the union of the spine with the head is rather farther back.

In examining the muscles of this animal, several were found which seem to have escaped the researches of Tyson, as well as the more recent observations of Camper and of Cuvier. The most remarkable muscle, about the top of the thigh, not noticed by these writers, is flat and triangular, arising from the whole anterior edge of the ilium to within half an inch of the acetabulum, and is inserted just below the fore-part of the great trochanter, between the head of the cruralis and vastus externus, a little below the origin of the former. As this muscle appears to be especially intended to assist in climbing, Dr Traill proposes to name it the *scandens* or *musculus scansorius*, and he regards it as one of the principal peculiarities in the simia satyrus.

In examining the internal parts of the brain, the usual horizontal sections were employed. The cineritious matter near the top of the brain, bore a larger proportion to the medullary than in the human body, but the proportional quantity of medullary matter became greater on penetrating to the level of the corpus callosum. The pineal gland was remarkably large. The whole quantity of brain weighed 11 ounces avoirdupois. Dr Traill conjectures that the proportion between the brain and body, was from $\frac{1}{30}$th to $\frac{1}{40}$th part; which approaches pretty nearly to that of man, in whom it varies from $\frac{1}{22}$ to $\frac{1}{31}$*. The quantity of brain, Dr Traill remarks, gives no indication of the intellect of animals, else monkeys, the mole, the mouse, the dolphin, and several birds should be greatly superior to the dog, the horse, the elephant, which last, of all quadrupeds, seems to have the smallest brain in proportion to his body.

The great size of the olfactory nerve, and the extensive surface of the turbinated bones, lead to the inference that the animal was endowed with an acute sense of smell.

After minutely describing the organs of voice, Dr Traill observes, that there does not appear any reason why the

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* See Cuvier, Anatom. Comp. tom. ii. p. 149.

orang outang should not speak. The organization strikingly approaches that of man, yet this animal, according to the best evidence, has never been known to make any attempt at articulate sounds. Its deficiency in this respect is to be referred, not to corporeal, but to mental peculiarities.

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## Art. XXIII.—*Account of the Opals of Hungary.*

The following account of the Opals of Hungary is translated and abridged from Beudant's Travels in Hungary: published in Paris, last year. [J.W.W.]

The most celebrated locality where the opal occurs is a village named Cservenicza*, in the trachytic formation which extends from Tokaj to Epériés. The mines have been wrought for many ages, and it is recorded that, in the year 1400, there were 300 workmen employed in the country of Cservenicza, both for working the opals, and the ores of mercury. At this time the number of workmen employed does not exceed 30.

The varieties of opal noticed by M. Beudant in these mines, were the opaque-opal of a yellowish or reddish white, and the milky opal, which is more or less translucent. The latter in some places assumes the character of menilite.

The fire opal is equal in lustre and beauty to that discovered by Humboldt at Mexico; it is still pretty common, but occurs in small masses, and these are so much cracked that it is almost impossible to cut them. Could it be obtained in large pieces free from fissures, it would be surpassed in beauty by no other mineral. The yellow colour appears to arise from the presence of iron, for on exposure to the blow-pipe it quickly blackens. M. Beudant considers the iron to be in the state of a hydrate.

Limpid opal is found free from colour in the interior of small geodes, which consist principally of opaque or milky opal; in these it forms a crust of variable thickness passing gradually into the contiguous layers. It sometimes occurs by itself in minute fissures, or is interposed in small layers in the substance of various kinds of opal.

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* Sclavon., Vörösvagás, Hung., pronounced Tchervenitza and Veu-reuche-vagâche.

Stalactitic opal (*l'opal concretionnée*) is found lining the sides of fissures and geodes. The small stalactites differing, when limpid, in no respect from hyalite, adhere more or less firmly to one another. When slightly heated they assume a pearly lustre and lose their coherence, when exposed to a red heat they break into small scales. Sometimes the stalactites are extremely minute, and completely fill the cavities, the small fissures by which the siliceous matter has penetrated the rock, being equally filled.

In some instances the opaline matter having formed but thin layers, an appearance of minute tortuous canals is produced, their surfaces being covered by very minute points. These surfaces are described as having the aspect of certain earthy pumices, with elongated and tortuous vesicular cavities.

Irridescent opal (*l'opale irisée*) is the principal object of research. It is abundantly disseminated in the rocks, but generally in very minute nests; it rarely occurs in large pieces. The working sometimes goes on for years before a piece occurs of the size of a 20 sous piece. The largest which has ever been found is in the imperial cabinet of Vienna; it is of the size of a man's fist, and weighs 17 ounces. This magnificent specimen has been at Vienna for more than two centuries, and it is not known when it was found. The polishing has been done irregularly to avoid diminishing its size. There are many fissures in it, and it is not completely disengaged from its matrix.

This kind of opal presents a great variety of colours; all the shades of blue, violet, red, yellow, green, &c. are blended in a thousand ways, and with the most brilliant and agreeable reflections. This beautiful stone is in great request and maintains a high price; the smallest piece, when beautiful, is not sold for less than 4 or 5 louis, (15 or 18 dollars,) and when large the value augments altogether beyond proportion. There is a very fine specimen at Kaschau, of the size of a small crown piece, for which 30,000 florins (10,000 dollars) were offered. It is said to have been purchased by the Baron de Brudern. The irridescent colours of opal are not owing to cracks or fissures; for these cannot be seen in the most beautiful specimens; and the smallest fragments present exactly the same play of light as the largest. The unequal distribution of vacuities, of different sizes, inclosing water, is the probable cause of this play of light; and it is easy, from the colours observed, to estimate the size, or rather the degree

of minuteness of these vacuities, upon the Newtonian theory of coloured rings.

Ferruginous opal occurs with the other varieties. It is impregnated with hydrate of iron. This variety is described by M. Beudant as passing into the opal jasper of Werner. It occasionally occurs in large nests, in which the opal is no longer to be distinguished, and to this variety are to be referred the specimens found in collections under the name of opal-jasper of Cservenicza. Sometimes the iron is so abundant, that the opaline matter discovers itself only by the resinous lustre it communicates to the mass. This mixture happens in all the varieties of opal; and it is this which constitutes the black opal (liver brown) which is rarely found possessed of the requisite beauty, as the reflections are destroyed by the mixture: it is much esteemed on account of its rarity; the reflections are dull, and most commonly violet or purple, all the other tints being absorbed by the colour of the basis.

Opals of all kinds are susceptible of alteration, becoming opaque, white, soft and adhesive to the tongue. Some by imbibing water regain their transparency and irridescence, constituting the hydrophane of mineralogists. This name is equally applicable to some calcedonies, which present similar phenomena, and hence the two minerals have been sometimes confounded.

In experimenting upon these altered opals M. Beudant found that they regained their transparancy when heated strongly before the blow pipe, and that at the same time they cracked, or split, which seemed to indicate a condensation of the substance, and to show in a different way from that hitherto known, that the opacity is owing to the vacuities contained in the stone. When the alteration and decomposition of the opal become complete, there results a white earthy matter, miscible with water, but not, however, so as to form a paste like argil.

Small nests of a white, soft, sectile matter, also exist in the most solid and freshest parts of the rock. M. Beudant is not inclined to believe that this is the result of a decomposition of the opal, as from being inclosed in the rocks, it could not have been exposed to the influence of the air, but that it is a particular state of the mineral. These earthy parts are regarded by the workmen as unripe opal. By desiccation the substance becomes harder, and cracks.

The sulphuret of iron occurs in the rocks in which opal is found, and the opal itself contains it in greater or less quantity;

it sometimes causes the decomposition of the rock, and even of the opal, in which it is contained.

Opal has been considered by some chemists as a hydrate of silica; by others, among whom is Berzelius, the water is supposed to be merely interposed. The latter opinion is founded on the fact, that silica cannot be made artificially to combine with water. M. Beudant does not speak decidedly in favour of either of these opinions; neither is he inclined to admit that opal and the minerals, which have been distinguished as silex resinite, and which differ essentially from hyaline quartz, have the same relation to the latter which compact carbonate of lime has to calcareous spar. All the circumstances under which opal occurs indicate a peculiarity of nature, which, though as yet imperfectly understood, is not the less evident.

Opal has been said to occur in Hungary, in beds of many feet in thickness; but M. Beudant always found it in nests, or rather veins, extending in all directions. This is the case at Cservenicza, where it has evidently filled either open fissures in the rock, subsequently to its consolidation, or irregular cavities, naturally existing in it. The walls of open fissures are in some places covered with opal; or cavities occur lined with stalactites, showing that the substance has been infiltrated. In other cases the manner in which the opal is disseminated in the rock, seems to indicate the contemporaneous formation of both.

The rock in which the nests and veins of opal occur at Cservenicza, has received various names, as lava, granite, porphyry, altered porphyry, brecciated porphyry, and hardened clay; some geologists viewing it as of volcanic, others as of aqueous origin. The opinion of M. Beudant is, that the mass of mountains in which this beautiful substance is found, is entirely formed of trachytic conglomerates, extending from the heights of Sovar to that of Kaschau, and which present a great number of varieties, according as the fragments of trachyte have been more or less broken up, more or less altered, and as they are more or less numerous in the paste which results from their comminution.

The central and most elevated parts of these mountains, resting immediately upon the trachyte, are composed of large blocks piled upon one another, having a finer conglomerate interposed. Small specimens of this conglomerate present many deceptive characters, and have led to numerous errors; but these are only infinitely small portions in the midst of a

mass of very distinct conglomerates. When observed in place, the intimate connection of the fine deposits with the coarser conglomerates composing the greater part of the mountains, is immediately perceived*.

The veins or nests of opal occur every where in these masses; they are found equally at the surface as deep in their substance. The veins or nests of opaque or milky opal are always more numerous, and larger than those of the irridescent variety. Cservenicza is not the only place where opal is found, and a number of other localities in the same group of mountains are noticed by M. Beudant. The trachytic conglomerate is not the only rock in which opal is found; it occurs in pumice conglomerate near Neusohl, and at some other places; but these opals are inferior in beauty, and have more of the characters of menilite.

Opal occurs in pearl stone at the extremity of the valley of Glasshütte, and at Telkebánya in the trachytic group of Tokaj. In the first of these localities, the opals are the opaque, and milky varieties. In the second, they are wax opals, and fire opals, like those brought from Zimapan, in Mexico, by M. de Humboldt, where they occur in the same matrix.

Opal Jasper. Werner has designated by the name of opal jasper, a particular species of jasper, having a basis of the nature of opal, and which occurs more or less mixed with foreign matters, among which the oxide of iron is the most important. This substance is still abundant in Hungary.

The purest opal jasper, which is only an impure variety of the semi-opal, (halbopal, of Werner,) presents a yellowish or greenish colour, with a waxy lustre. M. Beudant, indeed, considers it wax opal, in a particular state. In a more impure state it forms the earthy opal jasper, which adheres to the tongue. The characters of this variety, together with its mode of occurrence, forming as it does the outer part of the masses, which within are pure wax opal jasper, might lead to the belief that it is a state produced by decomposition. M. Beudant's observations show that this is not the fact.

When the quantity of iron increases, so that some parts of the masses appear loaded with it, another variety is produced, designated as ferruginous opal jasper. This has a blackish brown, or chesnut brown colour, with a resinous lustre. Hence it has been sometimes called pitch stone, although this

* Many of the remarks at page 494, tom. 3, are applicable to the conglomerate in the vicinity of Boston. W.

expression has been exclusively restricted by Werner to vitreous substances, with a somewhat greasy lustre, which, like obsidian, approach to the nature of felspar. Sometimes the entire mass is of oxide of iron, or of ochraceous matters, which are found here and there penetrated by the opaline siliceous matter. These masses are, in some parts, sufficiently considerable to be wrought as ores of iron.

Opal jasper passes into calcedony and horn stone, and beautiful carnelians are said to have been found in connection with those minerals.

Opalized wood. Opaque opal, more or less coloured, and opal jasper, by impregnating wood, buried in the midst of the debris of pumice, have given rise to opalized wood, (holzopal of Werner,) which presents a great variety of colours and degrees of lustre. In this case the siliceous matter has been successively infiltrated, and in the same manner as it has formed kidneys in the same (trachytic) conglomerates. Sometimes perfectly transparent opal is observed in the cavities of the wood, in small undulated nests, or in stalactites. In many cases the texture of the wood is preserved; and when the colour is also retained in an equal degree, it is impossible to distinguish by mere inspection, the petrified specimens from those which are in their original state. M. Beudant has sometimes been obliged to make an experiment to convince himself that the wood is not capable of burning. In some of the pieces, the tissue of the ash, in others that of the fir, are supposed to be seen; but most commonly it is almost impossible to form any idea of their original nature. In some instances, although the wood has passed into the opaline state, a fibrous tissue, and even flexibility, is preserved. M. Beudant conceives that the wood, in this case, was in part altered before it became petrified.

It is difficult to say whether the opalized wood has been silicified in the spots where it now occurs, or has been transported thither subsequently to its petrifaction. However, since opal jasper exists in the same places in true kidneys, and since the trunks of wood which occur, have no appearance of being rolled, it is probable enough that the place where they are at present found, is that in which they have been impregnated by siliceous matter.

All the declivities of the trachytic groups of Hungary furnish opalized wood in greater or less quantity; but the most remarkable locality is the village of Sajba, where the most

beautiful varieties are found. Almost all the specimens in collections have come from this place.

All the circumstances detailed by M. Beudant, confirm the remark, that the general position of these opaline matters is in the trachytic conglomerate, or sometimes in infiltrations in the trachytic rocks themselves. In fact, they present themselves in the same manner at Mexico, according to the observations of M. de Humboldt; and in the same way we find in Auvergne, opalized wood and opal jasper in the pumicose conglomerates of Mont d'Or and Mont du Cantal. It exists also in the same rock on the banks of the Rhine. In the Euganean mountains it occurs in the pearlstone, and its accompanying felspar rocks. It exists equally in the Phlegrean plains; in the Pumice and Lipari Isles, and in the island of Ischia. The Grecian Isles, Milo, Argentiera, Scorgotisa, and even Santorin, contain a great quantity, which is found also in the conglomerates. It appears, therefore, that this modification of the siliceous matter is peculiar to the trachytic formation, just as flint appears to be peculiar to the secondary calcareous, and jasper to the primitive or transition rocks. It is thus that the different kinds of minerals appear to be confined each to a particular formation, which is one of the most important facts of geology.

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Art. XXIV.—*Description of an Egyptian Mummy, presented to the Massachusetts General Hospital; with an Account of the Operation of Embalming, in ancient and modern times.* By John C. Warren, M. D., Professor of Anatomy and Surgery, in Harvard University.

This Mummy was sent to Boston by Mr Van Lennep, merchant of Smyrna, to be given to some public establishment, as a mark of respect to the city. This gentleman had requested Mr Lee, British Consul in Alexandria, to procure a mummy; and the latter, "having found," as he says in his letter, "that no good ones, opened, were to be found in this place or Cairo, commissioned a person going to Thebes to select one, and he succeeded in procuring the best that had been seen for a long time." On its arrival in Boston it was placed in the charge of Bryant P. Tilden, Esq., and Captain R. B. Edes, who thought they should best accomplish the in-

tentions of Mr Van Lennep, by presenting it to the Massachusetts General Hospital, in order to aid the funds of this charitable institution*. They requested my colleagues Doctors Jackson and Gorham, with myself, to open the cases, and examine their contents; and afterwards the trustees of the Hospital, having received the donation, desired me to give a description of it for the satisfaction of the public. The freshness and fine state of preservation of every part, led some persons to suggest that it might be one of those fabricated mummies, of which we have heard. These suspicions induced me to examine every thing belonging to it with great care, that I might be able, if it proved genuine, to do justice to the gentlemen who presented it, and to afford the Hospital the fair benefit of its exhibition. The results of this investigation, together with two drawings made from the outer case, I now beg leave to send you, for publication in your Journal, if you find them likely to be in any way useful.

It is a curious fact that the most perishable of substances, the flesh of man, should present itself to us as one of the most ancient remains of human art: for there is nothing which claims a higher antiquity than the mummies, not even the catacombs that enclose them, nor the pyramids in their neighbourhood.

In the oldest and most venerable of books, the practice of embalming is more than once mentioned in the earlier periods of the history of the Israelites. This people, during their residence in Egypt, naturally adopted the customs of that country. When Jacob died, Joseph commanded the physicians to embalm him. The embalming required forty days, and the same space of time was uniformly required for this process by the Egyptian embalmers. "Forty days were fulfilled for him, for so are fulfilled the days of those that are embalmed." Gen. c. l. v. 3.: and in the same chapter it is said, that Joseph also was embalmed, and put in a coffin in Egypt. v. 26. Jacob died in the year before our Saviour 1689; that is 3512 years ago: and as the practice appears to have been well established at that period, it must have existed long before; and been anterior to the time of the erection of the pyramids†. In truth,

* It is understood that a considerable sum has been already received for its public exhibition.

† If we adopt the account of Herodotus, the pyramids were built by successors of Sesostris: the first by Cheops, who was the fourth king from Sesostris; and the second, lately opened by Belzoni, was built by Cephrenes,

these structures were elevated by the same spirit which induced the Egyptians to embalm;—the desire to preserve and secure the bodies of the dead. This peculiar regard for the inanimate remains of their friends, arose from the extraordinary belief, that the soul did not quit its corporeal habitation at the time of death; but continued to be connected with the body, if it remained uncorrupted, until 3000 years were elapsed, at the end of which term, the soul was allowed to pass to another living body. If the body decayed at any time short of these 3000 years, the soul, having lost its place of residence, was compelled to inhabit the bodies of different animals in succession, until its full term was elapsed.

Subsequently to the time when embalming is spoken of in the holy scriptures, the first mention we find of it is in the historian Herodotus, more than a 1000 years after. This author, having himself visited and remained some time in Egypt, obtained from the priests of the country a multitude of curious facts, and among others a very minute account of the mode in which they embalmed.

"There are in Egypt," says he, "certain persons whom the law has charged with the operation of embalming, and who make a profession of it."—Having agreed about the price; in this manner they proceed to the most precious kind of embalming.—"First, they draw the brain through the nos-

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the successor of Cheops: and in this account Herodotus is supported by Diodorus Siculus. Sesostris lived in the year 3032: so that the pyramids were erected scarcely one thousand years before the christian era; and many hundred years after the deaths of Jacob and Joseph: in regard to whom the practice of embalming is first mentioned in history. But Manetho places the building of the pyramids at a vastly earlier period, and attributes them, at least the two larger, to some of the first Egyptian kings. The third pyramid is said to have been the work of queen Nitocris, who reigned in the year of the world 2332. The learned seem to be of opinion that Manetho is most to be trusted, in regard to the time of the pyramids; because these vast structures are entirely destitute of hieroglyphics, within and without, and of course must have been made before the reign of Sesostris; for at, and after his time, the Egyptian edifices were uniformly covered with hieroglyphics, almost without exception. It must be considered that Herodotus was in Egypt soon after its conquest by Cambyses; and could hardly be mistaken in a remarkable fact which happened only three or four centuries before; and that he expressly states there was an inscription on the first pyramid in Egyptian *letters*, mentioning the quantities of various articles of provision expended during this stupendous work. Belzoni has noticed, that some of the tombs, in the vicinity of the pyramids, contain stones placed with hieroglyphics upside down, as if they had belonged to another edifice; and it has been suspected that these might have formed the outer covering of the pyramids.

trils, partly by means of a curved iron, and partly by washing it out with medicated liquids. Then with a sharp Ethiopian stone, they make an incision in the side, and thence draw out all the bowels; which, when they have cleansed and washed with palm wine, are covered with odoriferous substances. Then they fill the cavity with pure myrrh bruised, cassia, and other odoriferous substances, except frankincense, and afterwards sew it up. When they have done this, they salt the body, by covering it with nitre (natron, or impure carbonate of soda) seventy days; for it is not lawful to salt it any longer. The seventy days being elapsed, they wash the body, and envelope it entirely with bands of cloth, covered with kommi, which the Egyptians commonly use for glue. It is then given up to the relations, who cause a wooden figure to be made with the likeness of the person, and having placed the dead body in it, they put it in a recess devoted to such purposes, standing strait up against the wall. In this way they prepare the dead in the most sumptuous manner.

"Those who wish to avoid expense, choose a middle sort of embalming. They fill syringes with an unctuous liquor, extracted from cedar, with this they inject the belly of the deceased, without making any incision, and without extracting the intestines. When this liquor has been introduced by the anus, it is stopped up to prevent the liquor from escaping; afterwards the body is salted, for the time prescribed. The last day they cause the injected liquor to issue from the bowels. This has so great power, that it dissolves the stomach and bowels, and brings them out with it. The natron consumes the flesh, and the skin and bones only of the dead person remain. When they have done this they return the dead, without further work.

"The third kind of embalming is for the poor. Having injected the bowels with surmaia, they salt it seventy days, and then deliver it to those who brought it.

"The wives of distinguished men, and such as are remarkable for their beauty, are not delivered to the embalmers until the third or fourth day*."

The account of Diodorus Siculus, who was in Egypt, 450 years after Herodotus, confirms in a great measure the description of the latter, and gives some additional particulars.

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* Herodotus, lib. 2. sect. 86. Ed. Laing.

"The manner of sepulture is threefold, the most costly, the moderate, and the most mean. The first costs a talent of silver; the second twenty minæ; the third almost nothing.

"Those who make a profession of burying the dead, have learnt it from their fathers.—The first, whom they call the scribe, the body being placed on the ground, marks about the left side how much should be cut. Then comes the parachist, or cutter, holding an Ethiopian stone, who, when he has cut as much as the law requires, immediately makes his escape, and is pursued by all those who are present, with stones and execrations, as if they would turn the sacrilege upon him.—They then proceed as soon as possible to the preparation of the body, and one, passing in his hand, removes all the viscera, except the heart and kidneys. Another washes them with palm wine and odoriferous liquids. Then they anoint the body for more than thirty days with cedar ointment, and having seasoned it with myrrh and cinnamon, not only to preserve, but to guard it from insects, they return it to the friends.—Hence many of the Egyptians, preserving the bodies of their ancestors in magnificent little edifices at their own houses, have wonderful satisfaction in looking at the bodies of those who have been dead for ages, but whose lineaments are so well preserved, that they seem as if they were still living."

The accounts of these ancient writers are in a great degree confirmed by the discoveries of modern travellers.—The incision is found on the left flank for removing the viscera, and the perforation in the ethmoid bone, for the extraction of the brain. We notice the appearance of odoriferous gums, of carbonate of soda, or some other saline substance; of bandages rolled many times round the body, and of the cases or coffins, carved into a resemblance of the deceased. Asphaltos or bitumen of Judea, so often found as the preserving substance, is not mentioned by either of these writers; for the kommi, spoken of by Herodotus, as the matter employed to glue on the bandages, must have been gum arabic. The use of asphaltos as an embalming substance is, however, mentioned by Strabo, and some other authors.

The effects of the cedria, the liquor extracted from the cedar, must have been misunderstood. At least we do not at present know in what way a substance, obtained from the cedar tree, could corrode the viscera so much, as to cause them to be discharged. It has been very naturally and judiciously suggested by M. Rouyer, that the corroding liquor

was the natron, or carbonate of soda, rendered caustic and dissolved. Or we may come nearer to the account of the ancients, by supposing that the cedar tree was employed to produce a caustic potass, to which this name, cedria, was applied; and that, after the use of this, a resinous or pitchy substance, obtained also from the cedar, was thrown into the cavity of the abdomen.

As to the surmaia, employed to preserve the bodies of the poor, we are not able to determine its nature. It might have been the substance called pis-asphaltos, or possibly turpentine; though we cannot believe that either of these, merely thrown into the abdomen, would have preserved the whole body. Mummies of the poor have been found in abundance, placed in the sands near the sepulchral grottos of the great. Some of these are tolerably preserved; yet appear to have had no other embalming substance than a covering of powdered charcoal; while others were filled with pis-asphaltos. Probably these and the others on whom surmaia was employed, were subjected to the desiccating power of the carbonate of soda.

M. Rouyer, one of the *savans* who were in Egypt with Bonaparte, made an exact examination of a great number of mummies, with a view of ascertaining the nature of the embalming substances. He informs us that near the ruins of Thebes, and in the neighbouring mountain, he found a great many mummies entire and well preserved. "It would be impossible," says he, "for me to estimate the prodigious number of those which I have found heaped up, or scattered in the sepulchral chambers, and in the multitude of cavities in the interior of this mountain."

He distinguishes them from each other in a manner conformable to the account of Herodotus, into those which have an incision in the left side, and those without. The class which have the incision, are again divided into those dried by the aid of balsamic substances, and those which have been salted.

The mummies preserved by balsamic and astringent substances are filled, some with aromatic resins, others with asphaltos.

The mummies filled with aromatic resins are of an olive colour: the skin is dry and flexible, like tanned leather, and seems to form a common mass with the flesh and bones; the features appear to be the same as during life. The abdomen and chest are filled with friable resins, which have no partic-

ular odour, but when thrown on burning coals produce a thick smoke with a strong aromatic smell.—These mummies are very light, dry, and easy to break; they preserve their hair and teeth. Some of them are gilt over the whole surface of the body, others on the face and hands. They seem to have been prepared with great care, and are unalterable so long as they are preserved in a dry place; but when exposed to the air, attract moisture, and in a few days exhale a disagreeable smell.

The mummies prepared with bitumen are of a black colour. The skin is hard and shining as if it had been varnished. The head, breast, and abdomen are filled with a resinous black substance, which presents the properties of bitumen. These are heavy, unalterable, and do not attract humidity. Many of them are gilt like the first species.

The mummies which have an incision in the left side, and which have been salted, are likewise of two kinds, one filled with resins, and the other with asphaltos or bitumen. Both of these are very numerous. When exposed to the air they attract moisture, and are then distinguished from the species not salted, by being covered with a light saline efflorescence, which appears to be sulphate of soda.

The second class of mummies, which have not the incision on the left side, nor any other part of the body, but from which the viscera have been, withdrawn through the anus, are also distiguishable into two sorts: first, those which have been salted and afterwards filled with a bituminous substance, and second, those which have been merely salted.

The first species of these are filled with a substance called pis-asphaltos,* less pure than the bitumen of Judea. Not only are all the cavities filled, but the surface is covered, and every part seems to be penetrated with it; so that it might be supposed the body had been immersed in a cauldron of the bitumen, while in a state of liquefaction. These are the most common of all: they are black, hard, heavy, difficult to break, and have a disagreeable penetrating smell. The bituminous matter is fat to the touch, less black and friable than asphaltos; dissolves imperfectly in alcohol; distilled, it gives an abundance of fat oil of a fetid smell.

The mummies, which are only salted and dried, are not so well preserved as those above-mentioned. It is rare to find them in an entire state; for most commonly the flesh is, to a

* The natural pis-asphaltos is, according to Dioscorides and others, a kind of bitumen flowing from certain mountains. It is found in various parts of the world.

greater or less extent, separated from the bones, leaving them quite clean and white. The skin is white and supple. The flesh, having been less dried is sometimes converted into adipocire, and lumps of this matter are also found in the cavities. They are strongly impregnated with a saline substance, which appears to be principally sulphate of soda.

Such is the result of the researches of M. Rouyer. Whence it appears that the most precious and most perfect mode of embalming, was, as stated by the ancient authors, with the resins. Next with asphaltos. The third with pis-asphaltos. The fourth and meanest with saline substances. It is probable, however, though M. Rouyer does not appear to be of this opinion, that the saline substance was equally employed in every mode; but that in the more perfect, it was carefully washed away before the resinous and bituminous substances were applied.

Whatever was the mode of embalming, he found the coverings of the bodies much the same: varying only in the number of thicknesses of bandage, or in the delicacy of its texture. Next the body there is found a close shirt, laced at the back and made tight at the neck. The head is covered with a square piece of linen of fine texture: the centre of which serves as a kind of mask; sometimes there are five or six of these, one over the other, and the last is gilt, and represents the countenance of the deceased person. Every part of the body is enveloped by separate bands, impregnated with resin; the legs are brought together and the arms crossed over the breast, and confined in this situation by bandages, curiously rolled round the whole body, to the number of fifteen or twenty thicknesses. The outer turns are covered with hieroglyphics, and secured by long bands artificially and symmetrically arranged.

Under the exterior bands are often found idols of gold, bronze, varnished earthen ware, painted or gilt wood, rolls of papyrus containing hieroglyphics, and many other objects which had a relation to religion, or were associated with circumstances dear to the individual while alive.

It is rare to find mummies enclosed in their cases; the pieces of these only being discovered. Many bodies were placed in the sepulchral caves, wells, and niches without; and those which had possessed cases, were generally thrown out of them. Those cases, which served, says M. Rouyer, for the rich, and for persons of great distinction, were double. That which enclosed the body was composed of a great number of thicknesses of a kind of pasteboard; and this was enclosed

in a second, made of sycamore wood or cedar. They were accommodated to the shape of the body they enclosed. The outer case had a likeness of the individual. It was composed of two pieces only, an upper and under, joined by projecting parts, secured with cords, externally covered with a simple layer of plaster, or varnish, and ornamented with hieroglyphical figures.

Belzoni says, that such as could afford it, probably had a case made to contain their bodies, on which was written a history of their life; while those in poorer circumstances had their lives written on papyri, rolled up and placed between their knees. In the appearance of the cases there is a great difference; some are plain, others very much wrought, and richly adorned with painted figures. The cases were generally made of sycamore, and always bear a human face, male or female. A few contain a second within them, of wood or plaster. The inner cases are fitted to the body of the mummy; though some of them appear to be merely covers, in form of a man or woman, easily distinguishable by the beard or breast. The wooden case is first covered with a layer of plaster or cement, not unlike plaster of Paris; and on this are sometimes cast figures in basso relievo, for which they made moulds. The whole case is painted, the ground generally yellow, the figures and hieroglyphics blue, green, red, and black, but the last colour is rarely used. Some of the colours appear to be vegetable, as they are evidently transparent; and the whole of the painting is covered with a varnish which preserves it effectually.

This traveller found, in some of the mummies, lumps of asphaltos, weighing two pounds. The entrails he saw bound up in linen and asphaltos; but Porphyry says, that after the entrails were removed from the body, the embalmer held them up to the sun, addressing to him a prayer, in the form of invocation; he declared, "that the body had not committed any crime during life; but that what faults might be imputed to it, ought to be charged to the bowels, which were then thrown into the Nile." For this account Porphyry has the support of Plutarch.

The mummies of the priests are supposed, by Belzoni, to be distinguished by the peculiar care with which they are arranged. The bandages are strips of white and red linen intermixed, covering the whole body, and forming a curious effect of the two colours. They have sandals of painted leather on their feet, and bracelets on their arms and wrists.—He found eight mummies in their cases, in the state in which

they were originally deposited. The cases lay side by side, flat on the ground, facing the east, in two equal rows, imbedded four inches deep in mortar; which must have been soft when they were deposited.

The preservation of so many of these mummies is partly attributable to the construction of the tombs in which they were deposited. The solid pyramids, the sepulchres of kings, were intended not more to prevent the intrusion of strangers, than to exclude air and moisture. The capacity of the catacombs under the city of Alexandria, now untenanted, even by the dead, has always excited the admiration of travellers. The numerous and profound excavations in the plains of Saccara were the cemeteries of Memphis; and the rocks of the Lybian mountains were penetrated to form the necropolis of Thebes.

In the last number of the Boston Journal of Philosophy and the Arts, there is an excellent description of some of the tombs. We can form a notion of the extent of these places from Belzoni, who says, he reached the inner apartments through passages, sometimes 300, and even 600 yards, or 1800 feet in length, formed in the solid rock. These passages are occasionally interrupted by thick walls, built for the purpose of closing them up; and they are broken by apartments of various dimensions, placed along their course, at different intervals, which served as separate depositories for the dead. They also present, in many places, square or rounded perpendicular excavations 30 or 40 feet deep, in the form of wells; on descending these, other horizontal passages and new apartments are found, some of which are ornamented in the most magnificent style. A part of the wells appear to have been intended to receive and carry off such moisture, as might accidentally find its way into the tombs.

The walls of these apartments and passages are so finely adorned with sculptures and paintings, that those travellers who view them, are at a loss for expressions of their admiration. The sculptures are generally raised from the rocky walls of the caverns, by cutting away the stone which surrounds the figure. The paintings are sometimes executed on the raised stone, sometimes on the plain surface of the rock, and often in a very fine plaster, applied to the walls of rock. The various figures represent Egyptian deities: the person buried in the tomb, perhaps a king or hero in his chariot, leading a triumphal procession, and followed by hosts of captive enemies; works of agriculture; of commerce; manufac-

tures; feasts; games and sports; battles and victories; generally concluded with a funeral procession. These paintings are very extensive; their colours are rich, and as fresh as if lately done; so that travellers hardly know which most to wonder at, the beauty of the work, or the perfectness of its preservation.

"It was not till after marching three quarters of an hour in this desert valley," says Denon, "that in the midst of the rocks we observed some openings, parallel with the ground, containing a door in a simple square frame, with a flattened oval on the upper part, in which are inscribed in hieroglyphics, a beetle, the figure of a man with a hawk's head, and two figures on their knees in the act of adoration. As soon as the first gate is passed, we discover long galleries cased with stucco, sculptured and painted; the arches of an elegant eliptical figure, are covered with innumerable hieroglyphics, disposed with so much taste, that notwithstanding the singular grotesqueness of the forms, the ceilings make an agreeable whole, and a rich and harmonious association of colours."—The sepulchral chamber is sometimes surrounded by a pilastered portico, whose galleries, bordered with recesses, supported in the same manner, and lateral chambers hollowed into the rock, are covered with a fine and white stucco, on which are coloured hieroglyphics, in a wonderful state of preservation; for except two of the eight tombs, which have been injured by water trickling down, all the rest are still in full perfection; and the paintings as fresh as when they were first executed; the colours of the ceilings exhibiting yellow figures, on a blue ground, are executed with a taste that might decorate the most splendid saloons.

Among the subjects represented, are sacrifices, and in one or more places are seen the figures of black men, decapitated, standing upright, with the head at the side of the body streaming with blood. Over the black men, stand one or more red men stretching out their arms in the attitude of invocation. These pictures concur with a multitude of other facts to prove, that the ancient Egyptians were not black but red; and that the black figures were made to represent Ethiopians. They can scarcely be intended for any thing but an exhibition of human sacrifices; and therefore lead us to suspect that Herodotus was misinformed on this subject; since he expressly says, the Egyptians never have human sacrifices. Or it is possible the practice might have been laid aside in his time; and that the figures allude to the habits of a much ear-

lier period, which the Egyptian priests would be apt to deny to Herodotus, after they had become obsolete and unfashionable, in consequence of the Persian conquest.

The finest of the tombs which have been lately opened, is that of king Psammis, discovered by Belzoni. This contains a long series of archways, corridors, halls, and chambers, to which M. Belzoni has given names; as the hall of pillars, the chamber of beauties, of mysteries, &c. It had never been opened by the moderns, though it appears that the Persians, Greeks, or Saracens had penetrated, and afterward closed it up. What the Persians spared, and the Greeks respected, M. Belzoni has contrived to carry off; for besides loading himself with the smaller objects, found in the tomb, he has got out a beautiful alabaster* sarcophagus, which had probably contained the remains of king Psammis, and this, together with the colossal head of the younger Memnon, and various other articles which no body else thought of disturbing, he has packed up and sent to England; and as if vexed at not being able to transport the tomb of king Psammis, with the rocky mountain which contains it, he has ingeniously formed, and set up in England, a representation of this tomb, with all its grottos, pillars, and paintings.

The most interesting among the groups, discovered in this place, is a military and triumphal procession of Egyptians, with their prisoners. The procession begins with four red men with white kirtles, followed by a hawk-headed divinity; these are Egyptians. Next follow four white men with thick black beards, and a simple white fillet round their black hair, wearing striped and fringed kirtles; these are Jews, and might, says the Quarterly Review, "be considered as portraits of those, who at this day walk the streets of London." After these are four negroes with hair of different colours, wearing large circular ear-rings, having white petticoats supported by a belt over the shoulder; these are meant to represent Ethiopians. Lastly, three white men with smaller beards and curled whiskers, bearing double spreading plumes in their heads, and wearing robes or mantles spotted like the skins of wild beasts; and these are Persians or Babylonians. Now it appears from the Bible† that Necho, the father of Psammis, went out of Egypt to fight with the Babylonians or Persians. In his way through Judea he was attacked by king Josiah,

* Since found by Dr Clarke to be arragonite.—*Ed. B. J.*

† 2 Chronicles, xxxv. 20.

and though he contended with him reluctantly, he conquered and killed him, and carried his son Jehoahaz prisoner into Egypt. The historian Herodotus states the same facts in a manner singularly accordant with the holy scriptures, and moreover, says, that king Psammis himself made a warlike expedition into Ethiopia; and thus we have explained to us the representation of the prisoners of the three nations, the Jews, Babylonians, and Ethiopians.

The Egyptians were not the only nation who preserved the bodies of the dead. The Guanches of the Canary Islands ollowed this practice to a considerable extent. They were conquered in the fifteenth century; yet there remain great numbers of bodies, prepared by them; a single cavern in Teneriffe, having been found, when first opened, to contain about a thousand bodies. Acosta and Garcilasso de la Vega inform us, that the Peruvians possessed this art, that the bodies of some of the Incas were found in a state of good preservation, and quite hard though light. The New Zealanders of the present day are wonderfully skilful in their preservations of the human body, though in other respects among the most ignorant and miserable of savages. The head of a chief or great warrior is thought to transfer to his enemies, if it happen to fall into their power, the courage and strength of the individual. They are therefore anxious to obtain and preserve such heads; and they are able to succeed so well in removing the causes of putrefaction, that the flesh is as solid and undecomposable as wood; possesses an aromatic odour like that of newly dried grass; and perfectly exhibits the features of the individual. I have one of these heads which belonged to a New Zealand chief; it might at first view be taken for carved work. The hair is wholly preserved; it was originally black, and somewhat finer than that of the American Indian, but is now red inclining to gray, from age. The forehead is narrow from side to side, and very oblique, though extensive. The jaws prominent, the teeth small. The skin is of a dark red or chocolate colour, tattooed over the whole face, and the cartilages of the nose cut to a point, so as to give a frightful and ferocious aspect to the face, more like that of a wolf than of a man. The art of these people probably consists in first cleaning the part to be preserved, and expressing the blood; then exposing it for some time to the steam of certain herbs, and afterwards drying it in smoke. It is said that they can prepare entire bodies in the same manner; but of this I am not well satisfied.

Natural mummies are bodies preserved without the aid of artificial means. They have been found in various parts of the world, and under different circumstances. In the exhumations of the great cemetery at Dunkirk, in France, a number of bodies were found in a state of preservation, intermixed with others in full putrefaction. Particular soils have a preservative, or rather a desiccative operation, and they appear to be especially such as abound in limestone. In Toulouse, in France, there are one or more churches, the cemeteries of which are said to possess this power. The operation of such soils is illustrated by an experiment made on two tritons. These small salt-water animals were placed, one in an empty glass vessel, the other in one containing some muriate of lime. On the second day the latter was found to be completely dried up; while the other remained alive until the fourth. Heat and cold both prevent the process of decomposition, though in different ways. The bodies of travellers in the burning sands of Africa, when buried by violent winds, are frequently dried and converted into mummies. While, on the other hand, various individual cases have occurred in those who died in cold weather, and whose bodies remained frozen for some time, of a desiccation sufficient to prevent the progress of putrefaction. 'We have an opportunity of seeing this process in venison, frozen, and kept in our apartments, which becomes dried, and undecomposable to a certain extent.' Whether we are to impute to the last cause, or to some other, the singular preservation of a gentleman's body near Boston, I am unable to determine. This body has been buried between twenty and thirty years, and is still so entire that the features of the face are at once recognised by those who knew him while living. I have examined it and found the skin quite firm and strong. The flesh of the arms is solid. The walls of the abdomen are perfect, and emit a hollow sound, as if the viscera had been removed or decayed. The skin is of a brown colour, and is constantly moist, though not wet. The cellular membrane under it is not fat, nor in the state of spermaceti, but precisely resembles the grain of the under surface of leather. This gentleman died, I believe, in the winter. He was about 80 years old, and very fat. The body was not opened, nor were any means taken to preserve it; and other bodies placed in the same tomb long since, are completely decomposed, even to the separation of the bones. It is remarkable that there is no worm, nor insect of any kind, seen in the coffin, or on the

body. The tomb is in the open air, placed somewhat on the side of a hill, facing the west, and the soil is rather of a dry nature. Although the fatty substance has now entirely disappeared, it is probable it had a principal agency in the preservation of this body, penetrating and preserving the muscles and other parts, while the desiccating process was accomplished.—The greater part of natural mummies are formed by the conversion of the flesh into adipocire, or spermaceti. This transmutation which has, within the last thirty years, been discovered in various situations as the effect of accident, has also been successfully imitated by placing flesh in wet places, and especially by exposing it to a small stream of running water. This has the effect of converting it, after a considerable time, into a spermaceti, that may be advantageously employed in the arts. Manufactures of spermaceti, on a large scale, are successfully carried on in this manner, particularly in Spain*.—All kinds of bodies are not equally susceptible of this decomposition. I suppose that those abounding with fat, and in which the muscles are tender, are the most proper subjects; but I have noticed in thin as well as in corpulent persons, who had lived in a very sedentary manner, that the muscular flesh has been nearly converted into spermaceti *during life*, so as to be ruptured by a very slight violence.

*False Mummy* is a term originally applied to a substance fabricated so as to resemble the embalming matter of the true mummies. Some centuries since, the asphaltos and resins which had been used for embalming, obtained great reputation in Europe as medicinal substances, especially in hypochondriac and nervous affections. The consumption was so great as to exhaust the repositories of Saccara; and the necropolis of Thebes was not then opened to a considerable extent. The Arabs and Jews succeeded in preparing the bitumen of Judea in such a manner as to answer the purpose of genuine mummy, for a length of time, until the discovery of the fraud, and the improvements of a later age, entirely put a stop to this branch of commerce. Another kind of false mummy is a wooden effigy of a man or woman, which has

* During the worst periods of the French revolution, when intercourse was cut off from the rest of the world, this fabrication was attempted in France; and it was thought a good revolutionary *bon mot*, in allusion to it, to say, "that some who had been of no use while alive might be made, after their death, to *illuminate* the world."

been sometimes discovered in the catacombs, arranged precisely in the way of the true mummies, and intermixed with them. Whether these were the falsifications of Egyptian embalmers, or whether it was one of the singular fancies of that people, which produced this kind of image, we are not informed*. A third false mummy is a poor attempt to imitate the true, by piecing together parts of different bodies, bundling them coarsely in rags, and enclosing them in a white-washed coffin. These boxes sometimes contained a bone or two, swathed in the form of a mummy. So gross an imposition actually passed, without being understood, for a considerable time. It does not appear that there ever has been a thorough and operose attempt to counterfeit a mummy with all its parts; nor in truth can such an attempt be profitable until the catacombs shall have been rifled, and emptied of thousands of bodies still remaining.

[To be concluded in the next Number.]

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Art. XXV.—*Account of a Man who lived ten Years after having swallowed a number of Clasp-Knives; with a Description of the Appearances of the Body after Death. Drawn up from papers published in the Medico Chirurgical Transactions:* by Alexander Marcet, M. D., F. R. S., &c., late Physician to Guy's Hospital. [J. W.]

The following extraordinary case is well worthy of being recorded, both from the singular nature of the facts themselves, and as affording a most striking illustration of the self-preserving powers of the stomach and intestines, and their ability to resist the influence of foreign agents. Although the circumstances occurred many years since, yet it is only within the last year, (1822,) that they have been collected and presented to the public in an authentic form.

In the month of June, 1799, John Cummings, an American sailor, about twenty-three years of age, being with his ship

* Perhaps these effigies are alluded to by Herodotus, where he speaks of an Egyptian custom, which might be revived at the present day, with salutary consequences. He tells us, "that in the feasts of the rich, when they depart from supper, some one carries round a wooden image of a dead man, painted and carved to an exact likeness, and showing him to each of the guests, says, 'Look on this, drink and take delight, for such shalt thou be after death.'"

on the coast of France, and having gone on shore with some of his shipmates, about two miles from the town of Havre de Grace, he and his party directed their course towards a tent, which they saw in a field, with a crowd of people round it. Being told that a play was acting there, they entered, and found in the tent a mountebank, who was entertaining the audience, by pretending to swallow clasp-knives. Having returned on board, and one of the party having related to the ship's company, the story of the knives, Cummings, after drinking freely, boasted that he could swallow knives as well as the Frenchman. He was taken at his word, and challenged to do it. Thus pressed, and though (as he candidly acknowledges in a narrative of his case, drawn up by himself,) "not particularly anxious to take the job in hand, he did not like to go against his word, and having a good supply of grog inwardly," he took his own pocket-knife, and on trying to swallow it, it slipped down his throat with great ease, and by the assistance of some drink, and the weight of the knife, it was conveyed into his stomach, The spectators, however, were not satisfied with one experiment, and asked the operator "whether he could swallow more?" his answer was, "all the knives on board the ship;" upon which three knives were immediately produced, which were swallowed in the same way as the former; "and by this bold attempt of a drunken man," to use his own expressions, "the company was well entertained for that night." The next morning he had a motion which presented nothing extraordinary; and in the afternoon he had another, with which he passed one knife, which, however, was not the one that he had swallowed first. The next day he passed two knives at once, one of which was the first, which he had missed the day before. The fourth never came away, to his knowledge, and he never felt any inconvenience from it. After this great performance he thought no more of swallowing knives for the space of six years.

In the month of March, 1805, being then at Boston, in America, he was one day tempted, while drinking with a party of sailors, to boast of his former exploits, adding, that he was the same man still, and ready to repeat his performance; upon which a small knife was produced which he instantly swallowed. In the course of that evening he swallowed five more. The next morning crowds of visitors came to see him; and in the course of that day he was induced to swallow eight knives more, making in all fourteen.

This time, however, he paid dearly for his frolic; for he was seized the next morning with constant vomiting, and pain at his stomach, which made it necessary to carry him to Charlestown hospital, where, as he expresses it, "betwixt that period and the 28th of the following month, he was safely delivered of his cargo."

The next day he sailed for France, on board a brig, from which he parted there, and embarked on board another vessel to return to America. But on his passage, the vessel was taken by the British ship Isis, of fifty guns, and sent to St. Johns, Newfoundland, where she was condemned; while he himself was pressed, and sent to England, on board the Isis. One day, while at Spithead, where the ship lay some time, having got drunk, and as usual renewed the topic of his former follies, he was once more challenged to repeat the experiment, and again complied, "disdaining," as he says, "to be worse than his word." This took place on the 4th of December, 1805, and in the course of that night he swallowed five knives. On the next morning the ship's company, having expressed a great desire to see him repeat the performance, he complied with his usual readiness, and "by the encouragement of the people, and the assistance of good grog," he swallowed, that day, as he distinctly recollects, nine clasp-knives, some of which were very large; and he was afterwards assured, by the spectators, that he had swallowed four more, which, however, he declares he knew nothing about; being, no doubt, at this period of the business, too much intoxicated to have any recollection of what was passing. This, however, is the last performance we have to record; it made a total of at least thirty-five knives, swallowed at different times, and we shall see that it was this last attempt which ultimately put an end to his existence.

The next day he was seized with serious symptoms of derangement, and applied to the surgeon of his ship, Dr Lara, for medical advice. He complained of excessive pain in the stomach and bowels, incapacity of retaining any thing on the stomach, and severe pain in walking or standing erect. These continued for some time, and were but little alleviated by the means made use of for that purpose. Little in fact could be done, under circumstances so remarkable, with any prospect of relief, and the case was left, in great measure, to the efforts of nature. A little castor oil was occasionally given to promote the expulsion of the knives downward, and opium administered to diminish the pain and vomiting, which

immediately occurred upon sitting up, or swallowing any thing solid. The evacuations from the intestinal canal became dark and inky. His appetite continued pretty good, but he became emaciated, though his pulse remained of the natural standard.

A general disbelief prevailed, notwithstanding these appearances, as to the cause to which Cummings attributed his complaint, particularly as some of those who had declared that they had seen him swallow the knives, prevaricated in their evidence on being repeatedly examined. He was directed, on account of this suspicion, to sit up the whole of the day. For a few days he always vomited on rising, but within a week he lost that symptom, and seldom vomited, except after drinking some liquid, and then it always had the appearance of ink and water. He had taken sulphuric acid and the muriated tincture of iron without benefit, and at this time the use of medicine was suspended. For three or four months there was little alteration; yet he seemed to gain in some respects, for although more emaciated, he was able to move about, and at intervals performed the duty of a sweeper on board the ship. On the 26th of April, 1806, nearly five months from the date of his swallowing the knives, he had a return of the vomiting and pain, which severely afflicted him for a few weeks, but from which he gradually amended, and was discharged to the performance of such light duties as he could execute.

For several months nothing particular occurred. He gathered strength and flesh, ate voraciously, drank proportionably, and performed some duty, though suffering from pain whenever he stood erect, and vomiting at intervals. On the 6th of June, he brought up by vomiting part of the horn handle of a knife, which occasioned him no considerable effort, or pain in its expulsion. On the 8th of Nov. he passed the blade and half the horn handle of a knife, with much pain. In the course of a few succeeding months, he evacuated from the stomach and from the bowels several other portions of knives, some of them with excruciating pain, and accompanied, on one occasion with hemorrhage from the stomach, to the amount of two pounds of blood.

In June, 1807, he was discharged from his ship, and immediately became a patient in Guy's hospital, under the care of Dr Babington. He was discharged, after a few days, his story appearing alogether incredible; but was readmitted by the same physician, in the month of August, his health during

this period having evidently become much worse. In the latter end of October, however, he was again discharged in an improved state; and he did not appear again at the hospital until the next September. He now became a patient of Dr Curry, under whose care he remained, gradually and miserably sinking under his sufferings, till March, 1809, when he died, in a state of extreme emaciation, three years and three months from the commencement of his difficulty. On his first admission into the hospital, his statement was entirely disbelieved, he was considered as a hypochondriac, probably labouring under some chronic affection of the stomach and liver, and was treated accordingly. Subsequently, however, the consistency of his story, and various symptoms attending his case, convinced his medical attendants that there was some probability in his representation. With a view to dissolve the bodies present in the stomach and alimentary canal, or at least in hopes of rendering their edges blunt, dilute acids, first the nitric, and afterwards the sulphuric, combined with opium and mucilage, were prescribed. Various other palliatives were also occasionally administered; and that these were attended with some temporary benefit, may be inferred from the long period during which the patient's life was preserved, notwithstanding the utterly hopeless nature of his situation.

On opening the body after death, various interesting appearances presented themselves. Throughout the cavity of the abdomen, a blackish ferruginous tinge prevailed, which was also observable in the hepatic system. On examining the intestines, one of the blades, and one of the back springs, were actually found in them, both so situated that their expulsion from the body was obviously impossible. The latter of these, about 4½ inches long, had literally transfixed the colon opposite the left kidney, and projected into the cavity of the abdomen; while another was found stretching across the rectum, with one of its extremities actually fixed in the muscular parietes of the pelvis. It was observed, that, although the knives had thus perforated the intestines, none of their contents had escaped into the cavity of the abdomen, and that no active inflammation had taken place; in consequence, no doubt, of the perforation having been gradual, and of a slow and simultaneous process of ulceration having taken place from within, which had enabled the parts to adapt themselves so closely around the protruding instrument, as effect-

ually to prevent any communication between the wounded intestine and the general cavity of the abdomen.

The stomach, viewed externally, bore evident marks of altered structure. Upon being opened, a great many portions of blades, knife-springs, and handles, were found in it, and deposited in the anatomical museum of Guy's hospital. These fragments were between thirty and forty in number; thirteen or fourteen of them being evidently the remains of blades; some of which were remarkably corroded, and much reduced in size, whilst others were comparatively in a state of tolerable preservation. That which had undergone the least alteration, being a blade made of cast steel.

The œsophagus at its lower part, and the upper orifice of the stomach, were thicker than natural. The left extremity of the stomach, where the spleen adheres to it, had its usual texture; but the right was exceedingly thickened. The rugæ, in the mucous membrane, were unusually prominent; and there were granulated projections from the edges of the rugæ. This membrane was coloured by the steel. The pylorus was natural, but the duodenum had a greater thickness than usual.

From a comparison of these particulars with the history of the case, it would appear, that so loug as the stomach was not injured in its action and texture, the passage of the knives was, in most instances, attended with no, or very little inconvenience. But from the frequent repetition of these experiments together with the man's habits of intemperance, the stomach at last lost the power of transmitting to the intestines those bulky and unyielding bodies. They therefore now remained in that organ, where they produced the distressing symptoms of indigestion and pain which have been described; and the circumstance of the knives not wounding the intestines till the latter period, was probably owing to a similar cause, namely, that when the stomach was able to expel them quickly, they passed through the intestines, inclosed within their handles, and therefore comparatively harmless; while at a later period, the knives were detained in the stomach till the handles, which were mostly of horn, had been dissolved, or at least too much reduced to afford any protection against the metallic part.

An opportunity was afforded by this dissection of noticing a chemical fact, which shows the power possessed by iron of impregnating the biliary secretions. The contents of the gall

bladder partook of the black tinge of the other abdominal viscera, and some of the bile was collected and examined by Dr Marcet, for the purpose of determining the presence of iron, as a constituent, and its proportion. About 150 grains of this bile, which was perfectly black, and possessed the usual alkaline properties, being subjected to evaporation, and the dry mass burnt in a platina crucible, with a little wax, the incinerated residue weighed nearly five grains; and on presenting a magnet, ferruginous particles were immediately attracted by it. This residue being treated with muriatic acid and prussiate of potass, the quantity of prussian blue formed, amounted to half a grain. This quantity was found to be more than double that contained in bile under ordinary circumstances; 150 grains of which, treated in a similar manner, yielded at most one fifth of a grain of prussian blue. This susceptibility of the bile, of receiving a ferruginous impregnation, appears the more remarkable, as Dr Marcet, some years before, attempted in vain to detect iron in the urine of persons, whose digestive system was under the influence of that metal.

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# General Intelligence.

*Proposed Instruments for ascertaining the mean Temperature, and the mean Atmospherical Pressure.*—A writer in the London Journal of Arts and Sciences has proposed a method, by which the mean of the atmospherical pressure, or the mean temperature, for any period, may be determined without the necessity of constant observation. He proposes to affix to the pendulum of a clock a column of mercury, which, varying in height, either by change of temperature, in the one case, or atmospherical pressure, in the other, will vary the centre of oscillation in the pendulum. The hours marked by a clock so influenced, compared with the actual lapse of time, must show the variation of the centre of oscillation; whence, may be directly inferred the mean height of the mercurial column. Perhaps the variation of temperature might be better ascertained, by simply constructing the pendulum rod of lead or zinc, which of all the solid metals are most affected by change of temperature; and making the comparison above proposed. Every body knows that clocks, hav-

ing pendulum rods of iron or wood, substances much less affected by heat than lead or zinc, are constantly disturbed from regular motion, by changes of temperature affecting the centre of oscillation. This variation of the centre might be much increased, by reversing the arrangement of the rods in a compensation pendulum, or by a combination of levers.—[D. T.]

*New Fermenting Apparatus.*—A patent has been lately obtained in England, for an apparatus, invented by Madame Gervais, to condense the alcoholic vapour which arises during the vinous fermentation. The apparatus consists of a conical vessel, which is placed over an aperture in the top of the vat which contains the fermenting liquor. This vessel is surrounded by cold water, and any alcohol which may arise in the form of vapour during fermentation, after being condensed by the cold sides of the vessel, is conducted through a pipe into the fermenting vat; while the permanently elastic fluids, which are always produced by fermentation, are suffered to escape by another pipe.

It is evident that such an apparatus must be advantageous, in proportion to the quantity of alcohol which escapes from the vat, during fermentation, in the ordinary mode. We should think it not unlikely that this is so considerable, as to render the condensing apparatus quite useful.—[D. T.]

*Condensation of Gases into Liquids.*—Mr Faraday has succeeded in condensing chlorine into a liquid: for this purpose a portion of the solid and dried hydrate of chlorine is put into a small bent tube, and hermetically sealed; it is then heated to about 100°, and a yellow vapour is formed, which condenses into a deep yellow liquid, heavier than water, (sp. grav. probably about 1.3). Upon relieving the pressure, by breaking the tube, the condensed chlorine instantly assumes its usual state of gas or vapour.

When perfectly dry chlorine is condensed into a tube by means of a syringe, a portion of it assumes the liquid form under a pressure equal to that of four or five atmospheres.

By putting some muriate of ammonia and sulphuric acid into the opposite ends of a bent glass tube, sealing it hermetically, and then suffering the acid to run upon the salt, muriatic acid is generated, under such pressure, as causes it to assume the liquid form; it is of an orange colour, lighter than sulphuric acid, and instantly assumes the gaseous state, when the pressure is removed. Sir H. Davy has given an account of this experiment to the Royal Society.

By pursuing this mode of experimenting, sulphuretted hydrogen, sulphurous acid, carbonic acid, cyanogen, euchlorine, and nitrous oxide, have been also found to assume the liquid form, under pressure, and to appear as limpid and highly mobile fluids. It is probable that other gases may be condensed by similar means, and that nitrogen, oxygen, and even hydrogen itself, may yield, provided sufficient pressure can be commanded.—[*Quar. Jour.*]

*Cleavelandite.*—H. J. Brooke, Esq., of London, one of the most accomplished mineralogists of Great Britain, has given the name of cleavelandite to the substance hitherto known as siliceous felspar, which accompanies the green and red tourmaline of Chesterfield, in Massachusetts. This mineral, and the albite, Mr Brooke remarks, are varieties of the same mineral. "Two different names having been given to this substance, it becomes necessary either to adopt one of them, to the exclusion of the other, or to assign a new one to the species.

"As the Albite is generally *blue*, and sometimes *red*,* its name might be applied with equal propriety to other substances. I have, therefore, preferred adopting the term cleavelandite to denote the species, out of respect to the Professor of Natural Philosophy, in Bowdoin College, U. S.

"This species has cleavages in three directions, parallel to the planes of a doubly oblique prism."

Mr Brooke has applied the name arfwedsonite to a foliated black substance, that accompanies the sodalite from Greenland; and the term latrobite to a substance, from Amitok island, near the coast of Labrador, which has a pink colour; like some of the varieties of lepidolite, is sufficiently hard to scratch glass, but is scratched by felspar, and is accompanied by mica and carbonate of lime.—[J. W. W.]

*Sapphirine.*—This mineral, discovered by Giesecké, in Greenland, contains, according to Stromeyer, alumina 63.1; silica 14.5; magnesia 16.8; lime 0.3; oxide of iron 3.9; oxide of manganese 0.5. It is a very different mineral from the sapphirine of Nose, which is a variety of haüyne, and from its hardness, and specific gravity, probably belongs to the corundum family.

*Eudialite*—Likewise discovered in Greenland, is interesting from the circumstance of the quantity of zircon earth

* "The specimen which first enabled me to determine the form, is bright blue. It came from Labrador."

and alkali it contains. According to Stromeyer, it consists of silica 53.325; zircon earth 11.102; lime 9.785; natron 13.822; oxide of iron 6.754; oxide of manganese 2.062; muriatic acid 1.034; water 1.801 = 99.685.

*Dichroite.*—The following are the results of the analysis of this mineral; silica 49.170; alumina 33.106; magnesia 11.454; oxide of iron 4.338; oxide of manganese 0.037; water and loss 1.204. The specimen analysed was from Greenland. The dichroite of Bavaria and Greenland, the hard fahlunite of Sweden, and the steinhelite of Finland, are supposed to be varieties of the same mineral.

*New Scientific Work.*—Among the new productions at the Leipsick Fair, was the first volume of MM. Martin and Spix's Travels in Brazil, during the years 1817, 18, 19, and 20; with an atlas, in imperial folio, of fifteen lithographic plates of portraits, views, geological and botanical charts, &c. This volume contains their travels through Rio Janeiro, St. Paul, Minas Geraes, Goyaz, Bahia, &c.—[*Ann. Phil.*]

Our readers may not be aware that, during the above years, a number of scientific travellers were traversing Brazil, under the protection of the Portuguese, and at the expense of the Austrian, Bavarian, and Tuscan governments. These gentlemen were, on the part of Austria, Professor Mikan, for natural history in general, and botany in particular; Dr Pohl, as mineralogist; M. Natterer, for zoology; M. Schott, as gardener; M. Socher, as huntsman; M. Ender, as landscape painter; M. Buchberger, as botanical painter; and M. Frick, as natural history painter. On the part of Bavaria, Dr Spix, as zoologist; and Professor Martin, as botanist. On the part of the Grand Duke of Tuscany, Dr Radi, as naturalist.

*Improved Method of obtaining Castor Oil.*—This method consists in mixing the seeds, deprived of their rind and beat into a paste, with a certain quantity of alcohol, (four ounces to the pound,) at 36° of the centigrade thermometer. This mixture is subjected to the press; the liquid flows with great facility, and is afterwards distilled; the residue of the distillation is washed with many waters. The oil separated by the water is placed upon a gentle fire, to evaporate all the moisture; it is then taken from the fire, and thrown upon filters placed upon a stove heated to 30° cen.; it filters freely, and the oil obtained is very clear and very mild. The products obtained in this way, are ten ounces of oil from each pound of the peeled seeds, and seven ounces from those with rinds on. These

products greatly exceed the quantity obtained by the old methods. Half the quantity of alcohol employed, may be recovered by distillation.—[*Jour. de Pharmacie.*]

*Geology of Lake Huron.*—On Feb. 21, and March 7, a paper was read before the Geological society of London, entitled, "Notes on the Geography and Geology of Lake Huron, including a description, accompanied by drawings, of new species of organic remains." By John Bigsby, M. D., M. G. S. In this paper the author enters, in some detail, into a geographical and geological description of the coast, and islands of Lake Huron. The greater part of the northern shore is composed of primitive rocks; while the Manitouline islands, which stretch nearly across the centre of the lake, with the southern coast, are entirely composed of secondary calcareous formations. To this paper is subjoined a map of Lake Huron, and plates, illustrative of the organic remains which are contained in great abundance in the limestone rocks.—[*Ann. Phil.*]

*Hydrocyanic Acid.*—Some chemists, as Lampaduc and Brugnatelli, formerly announced that the hydrocyanic acid might be obtained from prussiate of potass; but they did not sufficiently determine the manner in which it might be rendered of uniform strength. M. Gea Pessena, a chemist at Milan, has employed himself in removing this deficiency. The following is his process, which must be economical, if the result corresponds with the account of the inventor. He introduces eighteen parts of prussiate of potass and iron, reduced to a very fine powder, into a small tubulated glass retort, taking care not to soil the neck or side. He adapts to this vessel a very small tubulated balloon furnished with a conducting tube, which he plunges into the first flask, containing a little distilled water. The tube of the retort is to be hermetically secured; the whole left at rest for twelve hours, at the commencement of which the balloon is to be surrounded with ice; the neck of the retort is to be constantly cooled with wet cloths; afterwards the materials are to be heated with some burning charcoal, and preserved in this state until the streaks, which are observed in the neck of the retort, become more rare, and until a blue vapour arises, which threatens to pass into the receiver. At this point, the heat is immediately discontinued; the apparatus is allowed to cool entirely, and the contents of the receiver are poured into a proper vessel. The hydrocyanic acid obtained by this process has a strong and penetrating odour; the specific gravity is from 0.898 to 0.900, at the temperature of 13° or 14° of Reaumur: it like-

wise possesses, according to M. Pessena, all the properties of the purest prussic acid.—[*Giornale de Fisica.*]

*Hydriodate of Potass.*—The importance of preparing the various salts of iodine, used in medicine, with accuracy, is too obvious to require comment; we, therefore, regard the following directions respecting the hydriodate of potass as meriting attention.

One part of iodine, and three parts of water, are to be introduced into a phial or matrass; by degrees, and at intervals, an excess, one half part for example, of pure filings of iron is to be added. The combination immediately takes place; much heat is disengaged; the iodine disappears, and the liquid becomes of a deep red colour. During this violent reaction, a hydriodate, with excess of iodine, is formed, which has only to be heated, and constantly and slightly agitated, to be converted into a simple hydriodate of iron. The action is shown to be terminated by the almost complete absence of colour in the liquid, but still more certainly by white paper being no longer stained red by it. The liquid is to be filtered, and to be augmented by some parts of water; it is to be placed in a sand-bath, in a retort or matrass, and nearly at the boiling point; then the iron is precipitated by means of pure carbonate or subcarbonate of potass. This part of the process requires some attention, lest an excess of potass be added; which, however, may be separated by repeated crystallization, or saturated with hydriodic acid. After having filtered, in order to separate the ferruginous precipitate, and having washed it well, it is to be evaporated. The salt may be made to crystallize by cooling or by evaporation. In this latter case, the concentrated solution of the hydriodate of potass is to be placed, not upon a stove, because the salt would form along the sides of the vessel, and the liquid in the end be entirely re-mixed, but on a very gentle fire, where the edges of the vessel, being less heated than the bottom, may condense a little of the vapour which rises, and thus prevent the ascension of the salt. By degrees, crystals are deposited; when they fill almost all the space occupied by the liquid, it must be allowed to cool; then the mother-water is to be poured off, and again evaporated to obtain more of the salt; finally, the crystals are to be entirely dried at a stove or fire, where they undergo a slight decrepitation.—[*Jour. de Pharmacie.*]

*New American Locality of Rubellite and Lepidolite.*—We have lately received very interesting specimens of rubellite from Paris, in the state of Maine. The crystals are of the

usual form. They are in a granite, the felspar of which is similar to that of Chesterfield, (Mass.) and are accompanied with green and blue tourmaline, and lepidolite, of great beauty. The locality was discovered by E. L. Hamlin Esq., of Paris, to whose politeness we are indebted for the specimens.—[J. W. W.]

*Fusion of Carbonaceous Bodies.*—Professor Silliman has lately succeeded in fusing charcoal and plumbago, by means of Dr Hare's galvanic deflagrator. A detailed account of the highly interesting experiments by which fusion was produced, has been published by professor Silliman in his Journal. The melted carbon is obtained in small spheres resembling shot, some of them white, " like minute, delicate concretions of mammillary calcedony." Some of the globules, obtained from plumbago, were so hard as to scratch the hard green glass of which aqua fortis bottles are made.

Professor Silliman has also succeeded with the compound blow-pipe in melting plumbago and anthracite. The globules of melted plumbago obtained in this way, were, many of them, " white and transparent, and as large as small shot; they scratched window glass; were tasteless; harsh when crushed between the teeth, and they were not magnetic."

*Preservation of Leeches.*—The number of leeches every day used for the purpose of local bleeding is very considerable, even in England. There are four principal importers of leeches in London alone, whose average imports are said to be 150,000 per month each; making a total of 600,000, or 7,200,000, in one year. On the continent, where they are obtained at a much cheaper rate, the numbers employed are enormous.

In winter the leech resorts to deep water, and, in severe weather, retires to a great depth in the ground, leaving a small aperture to its subterranean habitation. It begins to make its appearance in March or April. Water alone is not the natural element of leeches, as it is supposed, but conjointly with ground or mud.

The usual food of the medicinal and trout-leech is derived from the suction of the spawn of fish; and leeches will not unfrequently be found adhering to the fish themselves: but frogs form the most considerable portion of their food. Hence, the best leeches are found in waters much inhabited by these animals.

The medicinal and trout-leech do not, I conceive, like the horse-leech, take any solid food; nor have they the like

propensity to destroy their own, or any other species of the genus; but these, the horse-leech will not hesitate to devour.

Leeches should be kept in large stone jars, which are unglazed; the lead, which is employed for this purpose, proving deleterious to this animal.

Wooden vessels are equally proper: indeed, leeches are now usually imported in small casks, the size of an oyster-barrel, each containing about 2000, instead of in bags, as formerly. These are peculiarly convenient for the purpose, having a head made of stout canvass, affixed to a hoop, which is screwed on, and removed at pleasure, thus admitting air to the leeches.

Pond or river water is the most proper for the preservation of leeches. It should not reach beyond the height of one half of the vessel; by which means, sufficient room is left for them to ascend from the water, whenever they are disposed so to do. The wholesale dealers prefer water which has been standing for a fortnight or three weeks; giving, as a reason, that the animalcula generated in it are necessary for their support; that, if the leeches be put into fresh water, they receive no nourishment until these animalcula are produced, and, in consequence, often become weak and unhealthy, through want of food. Water from ponds ought, therefore, to be preferred. It is not necessary or proper to change the water in the vessel so often as is commonly done; once in every two months in winter, and every month in summer is often enough, except under peculiar circumstances; as in very hot weather, when it may be changed once or twice a week; or upon the water turning bloody, an indication of disease among the leeches.

The vessels containing leeches should be placed in a situation secluded from all kinds of scents and effluvia; and so chosen as to preserve, as much as possible, an equality of temperature in all seasons.

When it is wished to preserve leeches for any length of time, they should be confined in small numbers, not exceeding four or six together, in earthen pots, holding about half a gallon. Each of these should contain about one pound of gravel, a quart of water, and be tied over with strong canvass; the more animalcula, small fish, &c. which inhabit the water, the better. But in case of deficiency of these, a small quantity of the fresh blood of animals, in a state of coagula, may be occasionally thrown into the vessels.—[*Price's Treatise on Leech-Bleeding.*]

(Continued from p. 15.)

Art. XXVI.—*Remarks on the Increase of the Population of the United States, and Territories of North America, with Original Tables deduced from the American Population Returns, to illustrate the various rates of Increase in the White Population and Slaves, and also the comparative degrees in which Agriculture, Commerce, and Manufactures prevail.* By George Harvey, Esq. Member of the Astronomical Society, &c. Communicated by the Author. [*Edin. Phil. Jour.*]

The Table which concluded the first portion of my Essay, in the last Number of this Journal, presents results of a more striking and remarkable nature, than any which have been drawn from the tables formed to illustrate the other divisions of the survey of the American population*. Since 1810, Indiana has added its immense increments to the Middle States, surpassing even the rapid rates of increase which distinguished Ohio in the former decade. In the Southern States, also, we find the returns for Louisiana presenting results scarcely less remarkable. And in the Territorial Governments, we have the fertile districts of Alabama, Illinois, and Michigan, each contributing their mighty increments, to swell and augment the tide of population.

Among the Northern States, it is curious to trace the growth of the district of Maine, when contrasted with that of Vermont. In the enumeration for 1790 to 1800, the increments of the former were decidedly inferior to those of the latter;

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* The reader is requested to correct the following typographical errors in the Tables belonging to the former part of this essay:—To place the sign *minus* before the number belonging to the free white males under 16 in Rhode Island, page 10.; also in the state of Connecticut, and in the class of males under 10, in p. 12. to substitute—0.4 for 50.4; and in the same page, to place the sign *minus* before the number belonging to the free white females of 45 and upwards. Also in the Table, p. 15., to introduce the same sign in the following places, viz. before the numbers for the males and females in the class under 10, in the states of Connecticut and Vermont; before the numbers belonging to the first, second, and fourth classes of males, and the first and second classes of females, in the state of Delaware; and, lastly, in the second class of males belonging to Illinois, to alter 37.3 into 347.3. *Author.*

The above errors were copied in our reprint, some of them were noticed in reading the article, as involving contradiction and obscurity, but not knowing in what the errors consisted, no correction was attempted. *E. B. J.*

and in the period from 1800 to 1810, the comparative rates of increase were somewhat of an uncertain kind, the ascendancy being found for some of the ages in one state, and sometimes in the other; but in the census for 1820, the district of Maine will be found to have gained a positive superiority in every age;—all the increments, and particularly those of the female class, being considerably raised above those of Vermont. In the latter state, indeed, we find the change to have been so remarkable, as to create decrements in its youngest class of males and females. Connecticut, likewise, is distinguished by decrements in its youngest classes; but the transitions are much less remarkable: for, in the former decade, the youngest class of males belonging to this state, was distinguished by a feeble diminution of its numbers; and the females of the corresponding class approached very nearly to a stationary state. But in Vermont, the change has been from increments of considerable and nearly equal magnitude, to decrements of a less equal kind. The second class of males and females has also undergone variations of a remarkable kind. The greatest increments which the population of this state received from 1810 to 1820, are in the three last classes of each of its sexes.

If we contrast the present Table for New Hampshire, with the results of the former decade, the increments will be found to possess some curious relations. The first, second, and fourth classes of its males, and also the first, second, third, and fourth classes of its females, for the last ten years, have increments inferior to the corresponding rates of increase of the former decade; but the increments of the classes of the two sexes for the latter period, exceed the corresponding ones of the former. In Massachusetts, with the exception of the last class, the increments alternate with the corresponding increments of the former period, from less to greater, and from greater to less. The first and second classes of males in Rhode Island, exhibit also a relation of this kind; and so also do the three last classes of females. The alternating changes which exist in the increments of Massachusetts, are not, however, to be traced in the fine province of New York, all the augmentations which its different ages have received, being inferior, in point of magnitude, to the corresponding increments of the preceding period. There is, however, a greater degree of uniformity, and a closer connexion, among the increments of this province, than in many others. In New Jersey, the increments for the first class of each sex are very intimately allied to each other in the two periods;

the rates of increase for the males being respectively 11.5 and 11.2, and the females 10.5 and 10.7. There is also a curious relation between the third and fourth classes of males for the two periods; the increment of the third class in the former decade being nearly double the increment of the same class in the latter decade; and the increment of the fourth class, during the last ten years, being also double the corresponding class of the former period. The small increments of the males and females of 10 and under 16, when compared with the other increments, afford a contrast somewhat remarkable. Pennsylvania is likewise distinguished for the close approximation of the increments of the first classes of its males and females, and so also are Maine, Massachusetts, Connecticut, New Jersey, Ohio, Georgia, Louisiana, Tennessee, Kentucky, and Alabama. These coincidences are, however, better exhibited in a Table.

| States and Territories. | Increments of the Males under 10. | Increments of the Females under 10. | Differences. |
|---|---|---|---|
| Maine, - - - - - | + 19.2 | + 18.9 | + 0.3 |
| Massachusetts, - - - | + 2.9 | + 3.6 | − 0.9 |
| Connecticut, - - - - | − 2.6 | − 1.8 | + 0.8 |
| New Jersey, - - - | + 11.2 | + 10.7 | + 0.5 |
| Pennsylvania, - - - - | + 26.6 | + 26.5 | + 0.1 |
| Ohio, - - - - - | + 139.5 | + 139.9 | − 0.4 |
| Georgia, - - - - | + 26.6 | + 26.2 | + 0.4 |
| Louisiana, - - - - | + 243.7 | + 244.3 | + 0.4 |
| Tennessee, - - - - | + 52.3 | + 51.7 | + 0.6 |
| Kentucky, - - - - | + 27.5 | + 27.7 | − 0.2 |
| Alabama, - - - - | + 192.5 | + 193.6 | − 1.1 |

The column of differences exhibits the close approximation of the male and female increments to each other; the positive signs showing that the excess is on the side of the males, and the negative signs that it is on that of the females. In no case is the difference greater than 1.1; and in by far the greater number of cases it is less than 0.5. The positive differences amount to +3.1, and the negative to —2.6, the difference between the two aggregates being only +0.5;—a coincidence as singular and remarkable as any before observed. And when we consider the diversity which reigns among the increments themselves, and connect with them the uncertain nature of the causes which have contributed to the growth of the population in the respective provinces, we cannot but consider it as singular that so close an approximation to equality should exist.

In the state of Delaware, the first, second, and fourth classes of males, and also the first and second classes of females, are distinguished by changes of a decreasing kind. Two other classes of the females, namely, the third and fourth, received only increments of a very feeble kind. The results also of the enumeration for the period comprised between 1800 and 1810, exhibited some singular relations, containing the only example of a class of persons, altogether stationary, and also of two other classes approximating very closely to the same state. In the decade from 1810 to 1820, there are likewise three classes of a similar kind. The magnitudes, also, of the increments of the last class of each sex, must be considered as very great, when contrasted with those which precede them. Causes of a very peculiar nature must have operated on the state of Delaware, to have produced such a series of increments as have here been referred to.

The equality which exists in the first class of the male and female increments of Ohio, has been already noticed; but it is also deserving of remark, that the fourth class of males possesses an increment precisely similar to the first. In the period from 1800 to 1810, the maximum male and female increments were found in the final classes; but in the succeeding census, it was only found to hold good in the females, the greatest increment in the male population being found in the third class. This circumstance is most probably to be accounted for, from the immmense number of young men who have been known to emigrate to the state of Ohio, in consequence, probably, of an impression which was at one time very strong in the public mind, that it possessed advantages superior to any other American state, and hence was resorted to by multitudes of the young mechanics of England.

In Indiana, notwithstanding the increments are so very great, a considerable degree of uniformity prevails among them, the average of the male rates being 513, and of the females 514.4,—a remarkable approach to equality, when the irregular nature of the operating causes is considered. This tendency of nature to produce a balance in her aggregate operations, is also curiously displayed in the state of Louisiana, where the male increments of the first and second classes, although but little more than half the magnitude of the third, and, we may add, the fourth increment also, and therefore presenting no kind of uniformity whatever; yet their means does not differ very widely, considering the magnitude of the increments, from the mean of the almost equally

irregular increments of the females; the former being 358.7, and the latter 342.9. It is remarkable, however, that the maximum female increment should be found in the final class, corresponding in this respect with Ohio, Indiana, Mississippi, Michigan, and Columbia;—Alabama being a singular exception to the law. The maximum male increments are found in the third class, in the states of Ohio, Indiana, Louisiana, Alabama, Illinois, and Michigan,—confirming the remark before made, relative to the immigration of young mechanics. A more particular account of the maximum increments will be given in a succeeding page.

Among the southern states, Louisiana, as has been already remarked, is distinguished by the magnitude of its increments, and also by the irregularity of their character. The impulse which its male population has received in the third and fourth classes, are among the most striking of the results which the present survey has disclosed. Next to the increments of the last-mentioned state, we may rank those of Tennessee, Kentucky, Georgia, and North Carolina, all of which present conclusions more or less interesting. Of the three remaining southern states, it is difficult to determine which is the greatest, from the uncertain nature of their increments. Of the two Carolinas, it may be observed, as somewhat singular, that the fourth and fifth increments of males, and the second increments of females, should so closely agree, notwithstanding the results of the other ages bear no perceptible relation to each other. Georgia and Kentucky also correspond in the first and third classes of their males. The large increments, moreover, which both the sexes of 45 and upwards received during this period in the two Carolinas, may not be unworthy of attention, particularly as they afford a striking contrast to the increments of some of the other ages. In Georgia, also, the first, third, and fourth classes of males, are respectively equal, or nearly so, to the corresponding classes of females, and likewise to the class of 45 and upwards. The first three classes, for both sexes, in the table devoted to the former census, exhibit likewise a close approximation to equality. Causes, therefore, somewhat of an uniform kind, have probably operated in Georgia during these periods, on particular classes of the two sexes.

Perhaps the most singular class of increments in the whole series, is that belonging to Alabama. Among the males, the most striking examples of disparity will be perceived to exist in the first three classes, and the two latter. The third class has an increment of 215.1 per cent., and the last only 62;

the latter an increment large, when regarded as indicating the rate of increase during so short a period as ten years, but small, when contrasted with so great an increment as the former. Such increments afford the means of discovering to which class of persons the province has been most indebted for its increase. It will be remarked, that the very large increments which belong to the third class, proves that a great number of young men must have emigrated to this territory, carried thither by the tide of fortune, and the adventurous spirit which the young possess. The increments of the first and second classes may have been produced as necessary consequences of the fourth and fifth; for these, consisting probably of by far the greater part of married persons, necessarily carried with them their families, and which circumstance contributed to give that impulse to the first and second increments, which they appear to have received. Perhaps some portion of the large increment of the third class may be attributed to this cause. It is very remarkable, however, that the state of Mississippi, which would seem to be almost as much subject to the uncertain influences of immigration as Alabama, should present results so very different from those last mentioned. For instance, the minimum increments for each sex are found in the class of 45 and upwards, in the territory of Alabama; whereas in that of Mississippi, the maximum increments of each sex are to be found in that class. The anomalies, also, which will be found to arise from comparing any corresponding ages together, in the states last mentioned, are very remarkable. If we select, by way of example, the first and last classes, for each sex, as in the following Table,

| Territories. | Increments in Ten Years. | | | |
|---|---|---|---|---|
| | Males. | | Females. | |
| | Under 10. | 45 and upwards. | Under 10. | 45 and upwards. |
| Alabama, | 192.5 | 62.0 | 193.6 | 93.1 |
| Mississippi, | 92.2 | 100.7 | 79.8 | 136.8 |

the results will be found of a very dissimilar kind. The large increment of Alabama, is succeeded by one of a comparatively small magnitude in both sexes; whereas in Mississippi, the contrary takes place, the lesser rate of increase being followed by the greater; and it would seem as if the

greatest and least rates of increase had mutually interchanged places with each other. How uncertain must have been the causes which contributed to produce conclusions so much opposed to each other as these! In Illinois, considering the great magnitude of all the increments, a greater degree of uniformity will be observed to prevail among them, than in either of the territories last reviewed. The transitions from one rate of increase to another, are not of so abrupt a kind as in those prevailing in the state of Alabama. In Michigan, the greatest male increment will be found in the third class, produced probably by the causes operating on Alabama. If we contrast the increments of the sexes of this state, as in the next Table,

| | Increments in Ten Years. | | | | |
|---|---|---|---|---|---|
| SEXES. | Under 10. | 10, and under 16. | 16, and under 26. | 26, and under 45. | 45, and upwards |
| Males, | 52.5 | 65.0 | 128.8 | 117.7 | 79.1 |
| Females, | 76.5 | 58.1 | 88.0 | 91.3 | 104.6 |

their great irregularities will be immediately apparent. If the results of the first column, for example, be compared with each other, no one could anticipate such conclusions as the third and fourth columns present, at least not from the ordinary laws of human procreation*.

In the observations which were before advanced, relative to the maximum increments from 1800 to 1810, a great degree of regularity was observed to prevail among them; and it was remarked, that both males and females could be separated into two classes, and that the greatest increments of each state fell in one or other of them. These classes were the third and fifth. The same principle has been attempted to be traced in the greatest increments contained in the table for 1810 and 1820, but not with the same success, two exceptions being found to it in the males, and five among the females. Nevertheless, the law before observed will be found to hold good, with respect to the males, in twelve states,

* For the use of those who may feel desirous of contrasting the rates of increase in Sweden, with those of the different American states (a subject on which it is my intention to offer a few remarks in another paper), the following Tables are added. To enable the comparison to be made with greater ease, the Swedish returns have been thrown into five classes, corresponding, as nearly as circumstances will allow, with the American divi-

in the class of 16 and under 26; and in eleven states in the class of 45 and upwards. Of the females, four states only will be found in the former of these classes, but in the latter sixteen;—another evidence in favour of the supposition, that it is the result of some law. The following Table, however, will more completely show the states and territories which conform to this law, and those which deviate from it. The females present the greatest irregularities.

| States and Territories in which the Maximum Increments of Males are found. | | |
|---|---|---|
| 16, and under 26. | 26, and under 45. | 45, and upwards. |
| Connecticut. | Massachusetts. | Maine. |
| New York. | Rhode Island. | New Hampshire. |
| New Jersey. | | Vermont. |
| Pennsylvania. | | Delaware. |
| Ohio. | | North Carolina. |
| Indiana. | | South Carolina. |
| Maryland. | | Georgia. |
| Virginia. | | Tennessee. |
| Louisiana. | | Kentucky. |
| Alabama. | | Mississippi. |
| Illinois. | | Columbia. |
| Michigan. | | |

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sions. It is a matter of regret to be obliged to depart, in an inquiry of this kind, from a classification of ages, so truly philosophical as that which has been matured by WARGENTIN, and the other enlightened members of the *Tabellvarket*, or Board of Population, to assimilate it to one less perfect and useful. Time, however, may do that for the American returns which it has done for the Swedish. Rome was not built in a day.

| Rates of Increase of the Swedish Population. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MALES. | | | | | FEMALES. | | | | |
| PERIODS. | Under 10. | 10 to 15. | 15 to 25. | 25 to 45. | 45 and upwards. | Under 10. | 10 to 15. | 15 to 25. | 25 to 45. | 45 and upwards. |
| 1757 to 1760, | + 4.1 | + 6.0 | − 0.2 | + 0.4 | + 0.0 | + 4.1 | + 4.7 | + 0.1 | + 2.7 | − 0.5 |
| 1760 to 1763, | + 0.3 | + 4.3 | + 7.6 | + 0.6 | + 2.9 | + 0.3 | + 7.1 | + 4.8 | + 3.7 | + 0.9 |
| 1763 to 1800, | + 27.2 | + 21.9 | + 33.9 | + 31.7 | + 40.4 | + 26.3 | + 19.8 | + 32.1 | + 29.4 | + 32.0 |
| 1800 to 1805, | + 3.4 | + 9.5 | + 3.4 | + 3.7 | + 4.6 | + 4.1 | + 9.9 | + 2.7 | + 3.2 | + 5.0 |

| States and Territories in which the Maximum Increments of Females are found. | | | | |
|---|---|---|---|---|
| Under 10. | 10, and under 16. | 16, and under 26. | 26, and under 45. | 45, and upwards. |
| Alabama. | Illinois. | New York.<br>New Jersey.<br>Pennsylvania.<br>Virginia. | Massachusetts.<br>Rhode Island.<br>Connecticut. | Maine.<br>New Hampshire.<br>Vermont.<br>Delaware.<br>Ohio.<br>Indiana.<br>Maryland.<br>North Carolina.<br>South Carolina.<br>Georgia.<br>Louisiana.<br>Tennessee.<br>Kentucky.<br>Mississippi.<br>Michigan.<br>Columbia. |

The preceding survey has afforded the most ample grounds for presuming, that the increase of the American population has not proceeded from procreation alone. To indulge such a supposition, indeed, would be to attribute to the operations of nature a series of irregularities of the most improbable kind. If we select, by way of example, the greatest and least rates of increase of the males, for the four great divisions of the states and territories, during the period last reviewed, as in the following Table,

| | | State or Territory. | Under 10. | 10, and under 16. | 16, and under 26. | 26, and under 45. | 45, and upwards. |
|---|---|---|---|---|---|---|---|
| Northern States, | Maximum, | Maine, | 19.2 | 14.7 | 39.8 | 25.6 | 44.3 |
| | Minimum, | Connecticut, | — 2.6 | 0.9 | 8.2 | 8.2 | 6.5 |
| Middle States, | Maximum, | Indiana, | 501.8 | 495.9 | 531.7 | 507.6 | 528.1 |
| | Minimum, | Delaware, | — 6.2 | — 0.1 | 7.1 | — 4.6 | 13.4 |
| Southern States, | Maximum, | Louisiana, | 243.7 | 250.2 | 457.8 | 443.1 | 398.7 |
| | Minimum, | Virginia, | 6.3 | 6.6 | 14.4 | 10.1 | 8.3 |
| Territories. | Maximum, | Illinois, | 365.8 | 347.3 | 388.6 | 329.8 | 375.0 |
| | Minimum, | Columbia, | 32.2 | 32.1 | 42.8 | 37.3 | 49.1 |

we must immediately admit the propriety of considering a very large proportion of the increase as arising from immigration. And although, in the present imperfect state of our statistical knowledge, it may be impossible to fix, with any

thing like precision, the several degrees in which procreation and immigration have prevailed, so as to produce results so singularly diversified as those which have been the object of the preceding pages to survey, there can be no doubt but that, in many of the states, the latter cause must have been decidedly the most powerful in producing them. On another occasion, an opportunity may be afforded for discussing these important relations; but, in the mean time, it may be remarked, that it does not appear, from the evidence with which we are at present furnished, that the laws which influence procreation in the New World are materially different from those which prevail in the Old. Subsequent inquiries, and more authentic documents than we at present possess, may throw a new light on the subject, and diminish the impression which has been made on the minds of many enlightened men, that the rapidity with which the American population has increased, is more to be attributed to immigration than to any other cause. Still the inquiry must be approached with caution, and, in the absence of so many necessary data, even speculation itself may be useless. If we consider, however, the present condition of Europe, and the causes which contribute to render the maintenance of a family difficult and distressing to the labourer, and contemplate the advantages which the western regions of America disclose, where the wages of industry are high, and where the *real* labourer enjoys the best fruits of the earth in abundance and peace, we may perceive at least some ground for presuming, that the effects of immigration have been great. In no antecedent state of the world has so immense and so indefinite a theatre been opened for the increase of the human race, not only, it is to be hoped, in number, but also in wealth, happiness, and virtue. At the present moment, we can contemplate a surface of fertile country upwards of 2000 miles in extent, reaching from the present remotest settlements to the shores of the Pacific Ocean, enjoying all the blessings of the temperate zone, intersected by innumerable streams, possessing the primitive and undecayed energies of nature, and capable of affording, for centuries to come, the best fruits of the earth in unlimited abundance.

It is in the newly settled states that we have met with the largest rates of increase; and there is no room for supposing, but that a large proportion of their inhabitants will acquire fixed and settled habits, and thus possess the means of calling into full and perfect exercise all the active principles of population. These considerations, joined to the farther influx

of other settlers, must, in subsequent years, give a prodigious impulse to their numbers. Some portion of the inhabitants of these new states will, it is true, retain their migratory habits; but this, so far from proving any check to the population, will rather be the means of increasing it more rapidly. On the uncertain frontier of the American territory, "where civilized gives place to savage life," crowds of such adventurous emigrants resort, "dispensing with the advantages, and exempted from all the restraints, of social life. Here they act in the double capacity of cultivators and huntsmen, partly civilized, and partly savage, until, by the advance of new emigrants, they are gradually surrounded with improvements on every side, and are at length brought within the pale of order and law. Tired of this control, and anxious to resume their free and licentious habits, they dispose of their lands to emigrants of a more settled character, and again take their station on the verge of the desert, there to bear the brunt of savage hostility, to hunt and to cultivate, and, by their resolute and ferocious habits, to repress the inroads of the exasperated Indians, and to act the part of successful pioneers, in clearing the way for the great mass of the American population. It is in this manner that the country gradually assumes the aspect of civilization, and that the dwellings of men are seen to take place of the haunts of wild beasts." The migratory habits of such men, so far, therefore, from proving any check to the increase of the population, actually prepare the elements for a more effectual advancement of it. The labours and difficulties of the few, become the means of promoting the happiness and welfare of the many. And in the states and territories which have been latterly peopled, a few years must produce a race of inhabitants attached to the country in which they have taken up their abode, from the exercise of those sympathies and attachments which so soon spring up, and find root in the human breast; but above all, by the strong conviction which they will most probably entertain, that their present condition is better than that which they have left.

It may also be remarked, that the principles of population will be called into more active exercise, in the early stages of a newly settled state, than in its late growth. This will appear manifest, when we consider, that, in the first settlement of a state, the most fertile tracts of country will be first occupied, and which, by affording the means of subsistence in greater abundance than when the less productive parts become settled, must necessarily give a greater impulse to the

population, in its former stages, than in its latter. It is also probable, that, by even supposing the agricultural population to predominate for a considerable period in the newly settled states, considerable diversities will arise among the increments of the inhabitants of different districts of the same territory, from the operations of the same cause. It is time, however, to hasten to the contemplation of a subject which makes a loud appeal to humanity,—the Slaves.

(To be continued.)

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Art. XXVII.—*Analysis of a Journal of a Voyage to the Northern Whale-fishery; including Researches and Discoveries on the Eastern Coast of West Greenland, made in the Summer of* 1822, by William Scoresby, jun. F. R. S., M. W. S., &c. &c. [*Edin. Phil. Jour.*]

The original design of the voyage, an account of which is given in the present work, was the prosecution of the whale-fishery on the coast of Greenland and Spitzbergen. Discovery, Captain Scoresby tells us, was an object, therefore, that could only be pursued subserviently to it, but it fortunately proved compatible with the principal purpose of the voyage. The choice of the fishing ground being left to our author, he preferred the coast of Greenland to that of Spitzbergen. This was not only, in his opinion, the most promising station for success, but likewise most agreeable to his wishes, as affording a chance of making important geographical discoveries. The result was highly satisfactory. The fishing proved successful, and an extensive unknown country was discovered. Wholly unassisted, and under very disadvantageous circumstances, Captain Scoresby executed the survey of a wild and terrible coast,—explored many of its sounds, bays, and islands,—and was also enabled to enrich science with numerous new and interesting observations and views.

The experience of these three or four last years having demonstrated the ruinous nature of the whale-fishery in Baffin's Bay, it will probably be entirely abandoned, and consequently the importance of the Greenland fishery, where the losses have been comparatively small, will rise in importance.

It cannot therefore be doubted, that the researches made during this voyage on the coast of Greenland, will prove of great consequence to our trade in that quarter, and that they will afford such information as may be the means of advancing the prosperity, and increasing the safety of those engaged in this adventurous employment. The re-discovery of the ancient Greenland colonies was also an interesting object in the voyage; and Captain Scoresby found, in every place where he landed, traces of human inhabitants, generally of Esquimaux; but, for reasons stated in the Journal, it appears that descendants of Europeans also formed part of its population.

In the Introduction to the Voyage, we are presented with a history of the ancient settlements on this coast, and of the many attempts made to re-discover them. Although all these attempts proved abortive, owing to the vast body of ice, extending to a great distance from the shore, it appears, from the observations contained in the Journal now before the public, that the coast is not inaccessible at present, but, on the contrary, that it may be visited annually. If the coast, from the Arctic Circle to Cape Farewell, be really defended by a barrier of ice, as is the general opinion, of the accuracy of which, however, our author has great doubts, the course he recommends to be pursued is a parallel betwixt the latitude of 69° and 75°, in some part or other of which limits, and frequently in many different places, the coast may be reached every summer; and, when the navigator once gets betwixt the land and the ice, there would be no great difficulty in reaching any of the stations of the old colonies, even down to Cape Farewell, the southern promontory of Greenland. Our author, in communicating his discoveries and observations, and in relating the various interesting incidents of the voyage, has chosen, and with great propriety, the journal form. We shall, therefore, in the account we are now to lay before our readers of the contents of this important work, adopt the same order.

The ship Baffin, commanded by Captain Scoresby, in which the voyage was made, appears to have been admirably fitted for the Greenland Seas. The various arrangements for the purposes of the whale-fishery were of the most complete kind, and nothing was neglected which could contribute to the comfort, and secure the safety of the crew. All the preparations and arrangements being finished, the Baffin sailed from Liverpool on the 27th March, 1822. On the 28th, they were forced, by stress of weather, into Loch

Ryan. During the leisure afforded by this detention, our author employed himself in constructing a temporary apparatus for obviating the errors produced on the rate of chronometers by the action of terrestrial magnetism on those parts of the instruments which are formed of steel. The weather having become favourable, they left Loch Ryan on the 7th April; on the 10th, passed the Island of Tiree; and the following day, at day-break, discovered the wild and solitary rock of St Kilda, which was passed at noon.

"The ship being now fairly at sea, the ship's company were divided into three 'watches,' containing an equal proportion of harpooners, boat-steerers, &c. This arrangement, which the large complement of a Greenland ship's crew renders easily practicable, gives each man, excepting on extraordinary occasions, 16 hours rest out of 24. This is a great relief to them in cold weather, and serves to compensate them for the extraordinary exertions to which they are sometimes called. At the same time, we appointed a crew of six or seven men for each of our seven whale-boats, for the purpose of getting them fully prepared and fitted for the fishery, and for keeping them in order when on service." p. 13.

On the 10th, they passed to the westward of the Faroe Islands, at no great distance; and, on day-break of the 14th, *fell in with ice*, about 150 miles to the eastward of Iceland, in so low a latitude as 64° 30′ N.,—a position in which Captain Scoresby had never before seen ice.

"It must," he remarks, "have been brought hither by a continuance of strong gales from the NW. Its effect on the climate of Iceland, the whole of which island the ice appeared at this time to envelope, must have proved both disagreeable and baneful to the inhabitants. In summer, the ice generally retires far from the coast; but during the preceding 18 months, it is probable that the northern parts of the island were never free from its chilling influence. Towards the end of August 1821, a season when the ice should have retired to its greatest distance from the shore, I found the promontory of Langaness encompassed by large streams of heavy drift-ice, which it appears never left the coast the whole of the summer. The effect of this on the temperature was most striking. In descending from Lat. 71° to 67°, the highest observation of the thermometer was 38°, and when close in-shore, near Langaness, it was 35° at mid-day, and 32° early in the morning. It might be reasonably expected, that such a degree of cold in the height of summer would be

destructive to vegetation, and, consequently, most dangerous to the cattle, whose supply of herbage in this quarter is at all times scanty; yet, in the interior, we are informed, by the Danish journals of the period, that the summer of 1821 was uncommonly warm." p. 14, 15.

On April 15. they forced their way through the ice, and got clear of it in the evening. The weather all day was delightful. The Latitude at noon was 64° 41′. An hour or two before midnight, a splendid aurora borealis made its appearance, and the following excellent description is given of it.

"It commenced in the north, and extended itself in an arch across the zenith, towards the south. A sort of crown was then formed in the zenith, which was most brilliantly illuminated, and gave out innumerable coruscations of great beauty, and with astonishing velocity. The light appeared to be equal to that of the full moon; and various colours, particularly blue, green, and pink, were stated by my officers to have been clearly observed. Its extreme distinctness, and the boldness of the coruscations, seemed to bring it to a low elevation; and, when the rays were darted towards the ship, it appeared almost to descend to the very mast-head.

"Between the parallels of 62° or 63° and 70°, the aurora borealis is of very common occurrence, in the spring and autumn of the year. On the 3d of April 1820, I observed the most interesting display of this meteor that nearly forty passages to and from the fishery had afforded. The evening was fine and clear, the wind westerly. The aurora first appeared in the north, and gradually extended in a luminous arch across the zenith, almost to the southern horizon. A dim sheet of light then suddenly appeared, and spread over the whole of the heavens to the eastward of the magnetic meridian, while only a few insulated specks were visible to the westward. The eastern aurora were gray and obscure, and exhibited little motion; but the arch extending across the zenith, showed an uncommon playfulness of figure and variety of form. Sometimes it exhibited a luminous edge towards the west, in some places concentrated into a fervid brilliancy. The rays were a little oblique to the position of the arch; but generally parallel to each other, and commonly ran in the direction of the magnetic north and south. At one time they extended sideways against the wind; at another in the contrary direction. Now they shot forward numerous luminous pencils, then shrunk into obscurity, or

dispersed into the appearance of mere vapour. The colours were yellowish-white and greyish-white. All the stars of the fourth magnitude were visible through the meteor, even in its most vivid coruscations. *Ursa Major* was at one time encircled with such a characteristic blazonry of light, that the Bear seemed to spring into figure, and to be shaking his shaggy limbs, as if in contempt of the less distinguished constellations around him. The Pleiades were almost obscured by the light produced by the aurora; though Venus, and all the superior stars, shone with becoming splendor. I have never been sensible that the shooting of the aurora was accompanied by any noise; the turbulence, indeed, of the water at sea, or noise of the sails during calms, prevents slight sounds from being heard." p. 16—18.

For some days after the aurora borealis, the weather was fine. During a run of 50 leagues, the sea was constantly of an olive-green colour, remarkably turbid; but, on the afternoon of the 17th April, it changed to transparent blue. This green appearance of the sea in these latitudes, was occasioned by myriads of small marine animals. A calculation of the number of these animals, in a space of two miles square, and 250 fathoms deep, gave an amount of 23,888,000,000,000.

Their Latitude, on the 17th, was 65° 58′, Long. 3° 53′ W. A great quantity of drift-wood passed during the day. Two trees were picked up, one of which was about 30 feet in length. This wood is probably derived from some of the great rivers of Siberia, which empty themselves into the Frozen Ocean, and being carried by the westerly current prevailing on this coast, is dispersed throughout the Greenland Sea. The wood is pine and birch. It is not uncommon to find trees imbedded, in an upright position, in the middle of large sheets of ice,—a circumstance which, our author remarks, is in favour of the supposition of such ice having been formed near land. On the 18th, they again fell in with ice. The day following, at noon, having had a good run during the night, Captain Scoresby observed in Lat. 68° 45′, Long. by chronometer, 0° 8′ W. The variation was found to be only 14° W., on a NE. by E. course, but the real variation must have been about 22°, the difference of 8°, being the effect of the "local attraction" of the ship on the compasses.

"The amount of 'deviation' on every point not being yet ascertained, nor the points of change, we sailed in considerable uncertainty, whenever an alteration in the course was necessary. The Baffin having an iron-tiller, and much heavy

iron-work about the rudder, has an extraordinary deviation in her compasses. In her first voyage (1820), it was still more considerable, and not a little dangerous before it was discovered. It produced an error of a degree of latitude in one day's run, on a NE. by E. course,—the deviation on that point being twenty-two degrees. On carrying a pocket compass round the quarter-deck, to ascertain the cause of attraction, I discovered that it was principally owing to the piping or chimney of the cabin-stove, which had inadvertently been made of sheet-iron, and had consequently an attractive energy (according to Mr Barlow's investigations) equal to a pillar of solid metal, of the same quality and diameter. On removing this chimney, though eight feet distant from the binnacle, the deviation was diminished more than two-thirds." p. 21, 22.

On Sunday, the 21st April, had a hard gale from NE. and NNE., but which having been foreseen by means of the barometer, proper precautions were taken to secure the vessel from its effects. A little before sunset on the 22d, a *weather-gall* (or the limb of a rain-bow) of great brilliancy, appeared. The weather-gall is generally considered by seamen as the harbinger of a storm; and we find, from the Journal, that the next day was stormy. On the 25th, observation was made in Lat. 75° 5′. For two or three nights preceding this, Captain Scoresby says, "we had no darkness, but only faint and diminished twilight. Now we were advanced into the regions of continued day, where the sun, for months together, sweeps round the North Pole without ever descending below the horizon."

Having now reached a *fishing latitude*, preparations were made for the fishery. The number of boats was seven. In each of them were coiled six whale-lines, of 120 fathoms. They were also fitted up with all the apparatus of harpoons, lances, oars, axes, flags, &c. as usual in their equipment. On the 27th April, at 5 P. M., the ship passed the 80° North Lat., being within ten miles of Hackluyt's Headland, in Spitzbergen, *a latitude which was reached without experiencing any frost.* In the evening, the wind coming off shore, the sky immediately became clear, and displayed a large extent of the northern coast of Spitzbergen, of which the following description is given.

"This coast is much lower land than the western, and more uniformly covered with snow, few ridges, or even points of naked land, being visible. The western coast, on the other hand, presents alternate streaks of black and white.

The former colour, consisting of ridges of naked rock, which appear black, contrasted with the brilliant whiteness of the snow, frequently runs from the summit directly towards the base of the mountain, but oftener becomes concealed beneath a bed of snow and ice, as it approaches the water's edge: the latter colour, the white, consisting of snow and ice, fills all the ravines, dells, fissures, and vallies, and reflects the light of the sun with such intensity, that the tracts of snow-clad land exhibit, as near as possible, the colour and splendour of the moon at the full. The ice and rocks being thus highly illuminated, and strongly contrasted,—being constructed on a majestic scale, and rising with peculiar steepness out of the sea,—give a character to the Spitzbergen scenery highly striking, interesting, and indeed magnificent.

"As soon as we passed to the northward of Cloven Cliff, the north-western land of Spitzbergen, the whole of the northern coast was seen through a highly and unequally refractive medium. In consequence of this, the cliffs were reared to an uncommon altitude, and presented the beautiful basaltic character, which it is a general property of this remarkable state of the atmosphere to produce. The apparent columns were all vertical, or nearly so, and, when slightly waved, maintained their parallelism, the curvatures of the adjoining columns corresponding with each other." p. 26, 27.

In the passage from Liverpool to this station, only the usual birds of the latitudes passed, which are enumerated, were met with*. They now continued to approach the Pole, in a sea clear of ice to the NW. and W., until one in the morning of Sunday the 28th, when, in Latitude 80° 30′, they were stopped by the main northern ice. In the afternoon of this day it fell calm. Snow began to descend, and the mercury in the barometer sunk to 29° 40′, thus announcing a gale, which speedily followed. Next morning the wind moderated, and a heavy fall of snow commenced. This circumstance, with a low state of the barometer and a heavy sea, indicated a renewal of the gale from another quarter. The wind chopped round to the northward, and it presently blew very hard. This sudden change of the wind occasioned a great decrease of temperature; for in the space

* *Procellaria pelagica*, near Harris; *Pelecanus bassanus* off Faroe; *Procellaria glacialis*, from Harris to Greenland; *Larus rissa, parasiticus, glaucus, eburneus*, were frequent: on approaching Spitzbergen, *Alca alle, Colymbus grylle, C. troile, Sterna hirundo, Emberiza nivalis*, &c.

of sixteen hours, the thermometer sunk from 32° to 0°—2°, being a fall of 34°, the most remarkable range of temperature ever experienced by Captain Scoresby in the Greenland seas. On the 30th April, when the sun broke through the clouds, a change of temperature was produced from 3° or 4° below zero, to + 14°; and further, the side of the ship on which the sun shone was heated to 90° or 100°, and the pitch about the bends became fluid. Thus, while on one side there was uncommon warmth, on the opposite was great cold.

On the 1st May, at 5 A. M., Captain Scoresby calculated that he had advanced to 80° 34′, a distance of only 566 miles from the Pole; but the increasing accumulation of ice to the northward, and the want of whales, did not encourage further sailing in that direction. They were now within a short distance of the extreme accessible point of the Greenland ice towards the north; "and the Baffin," says Captain Scoresby, "was, without question, in the highest latitude of any ship at that moment on the sea; and there was no doubt on my mind, when I stood on the taffrail, as the ship was turned before the wind, that I was then nearer to the Pole than any individual on the face of the earth." They continued cruising amongst the ice under various latitudes in search of whales; and the first was captured on the 6th of May, in Latitude 79° 31′ N. On the 9th of May the cold was intense, being—8°, the greatest degree of cold experienced by Captain Scoresby during twenty voyages to Greenland.

"Though we had smooth water, and kept the companion-door constantly closed, the cabin became more uncomfortable than the deck. Water spilt on the table, within three feet of a hot air-stove, became ice; washed linen became hard and sonorous; and mitts that had been hung to dry exactly in the front of the fire (the grate being full of blazing coals), and only thirty inches distant, were partially frozen; and even good ale, placed in a mug at the foot of the stove, began to congeal! A damp hand applied to any metallic substance in the open air stuck to it; and the tongue brought into contact with the same, adhered so firmly that it could not be removed without the loss of the skin. Some of the sailors suffered considerably from partial frost-bites. The cooper had his nose frozen, and was obliged to submit to a severe friction with snow; and the boatswain almost lost his hearing." p. 43, 44.

On the same day several parhelia or mock suns were seen. The nautical operations of this day were of the most difficult

opening, so as to permit our passing through towards the north-west. At the extremity of the first opening, or lake, there was a compact barrier of floes, wherein, however, after a few hours detention, we discovered a narrow dubious channel, that eventually conducted us into the expanse of water pointed out by reflection in the atmosphere." p. 80, 81.

The night of the 7th—8th, was stormy, with snow or fog; but in the afternoon the sky was clear, when land was discovered extending from N. by E. to NW., the nearest part supposed to be at the distance of fifty miles. This was the eastern coast of Greenland, being a continuation towards the north of that coast, on which the ancient Icelandic colonies were planted in the tenth century.

"I looked on it," says our author, "with intense interest, and flattered myself with the hope of being able to land upon some of its picturesque crags, where European foot had never trod, before the season for the fishery should come to a close. As no ship had ever before penetrated (I had reason to believe) within sight of this coast, at so early a period of the summer, I was encouraged to expect that my wishes would not be difficult to accomplish; and, as the main design of my voyage was fortunately compatible with researches about this unknown region, I determined immediately to penetrate, as far as possible, towards the shore." p. 82, 83.

Their latitude being 74° 6′, the southernmost land in sight was considered as the Hold-with-Hope of Hudson, and the most northerly as Gale Hamkes' Bay. On attempting to proceed to the northwest, they were interrupted by a solid barrier of fields and floes of ice, closely wedged together. They were therefore forced to remain until some change in the ice should take place. Captain Scoresby, in rowing amongst the ice, was struck with the numerous remarkable forms it assumed, and of which a particular account, illustrated with plates, is given in the Journal.

The ship still continuing beset, Captain Scoresby employed his leisure hours in making observations on the local deviation of the Baffin; and of which a highly curious and detailed account is given in the narrative. Early in the morning of the 11th June, during a perfect calm, the pressure of the floes relaxed, which enabled the ship to get nearer to the coast. On the 12th of June, the land being only ten or fifteen leagues distant, drawings were made of its appearance, and a set of observations on its bearings. The nearest approach to the land was about ten leagues; beyond

that limit it was impossible to advance, on account of the barrier of ice. The weather, however, was clear; and the coast, for an extent of ninety miles, was constantly visible; and the various headlands, owing to their great elevation, were strongly shown; so that a tolerable survey was made of the more prominent parts of the coast. In carrying on this work, Captain Scoresby had already five or six stations determined astronomically, and had employed upwards of fifty angles or bearings. The general trending of this coast, extending from Gale Hamkes' Bay, in Lat. 75°, to Bontekoe Island and Hold-with-Hope, in 73° 30′, is SSW., true. It is almost wholly mountainous and barren, and its ordinary height 3000 feet. Of this land, only a few points had been previously named; and, therefore, Captain Scoresby properly considered himself entitled to give names to the others; and hence we have Kater's Bay, Wollaston Foreland, Scott's Inlet (in honour of Sir Walter Scott), Home's Foreland, &c. In the midst of his operations for the survey of this coast, it fortunately happened that the moon, at a convenient distance from the sun, for determining the longitude, became visible, and this valuable opportunity was not lost. From six sets of distances and latitudes, he obtained the mean longitude of 17° 54′ 30″ W., for the place of the ship on the 14th June. These observations for the longitude, enabled Captain Scoresby to ascertain the exact effect in a particular case, of the extraordinary refractive property of the atmosphere in the Arctic Seas, which, without such proofs, would scarcely have been credible.

"The coast that has just been described, is in general so bold as to be distinctly visible, in the ordinary state of the atmosphere, at the distance of sixty miles; but on my last voyage into these regions, one part of this coast was seen, when at more than double this distance. The particulars were these:—Towards the end of July 1821, being among the ice in Lat. 74° 10′, and Longitude, by lunar observation and chronometer (which agreed to twenty-two minutes of longitude, or within six geographical miles), 12° 30′ 15″ W., land was seen from the mast-head to the westward, occasionally, for three successive days. It was so distinct and bold, that Captain Manby, who accompanied me on that voyage, and whose observations are already before the public, was enabled, at one time, to take a sketch of it from the deck, whilst I took a similar sketch from the mast-head, which is preserved in my journal of that year. The land at that time nearest to us was Wollaston's Foreland, which, by late sur-

veys, proves to lie in Latitude 74° 25′ (the middle part of it), and Longitude 19° 50′; the distance, therefore, must have been at least 120 miles. But Holme's Foreland, in 21° W. Long., distinguished by two remarkable hummocks at its extremities, was also seen; its distance, by calculation, founded on astronomical observations, being 140 geographical, or 160 English miles. In an ordinary state of the atmosphere (supposing the refraction to be one-twelfth of the distance), any land to have been visible from a ship's mast-head, 100 feet high, at a distance of 140 miles, must have been at least two nautical miles, or 12,000 feet in elevation; but, as the land in question is not more than 3500 feet in altitude (by estimation), there must have been an extraordinary effect of refraction equal to 8500 feet. Now, the angle corresponding with an altitude of 8500 feet, and a distance of 140 miles, is 34′ 47″, the value of the extraordinary refraction, at the time the land was thus seen: or, calculating in the proportion of the distance, which is the most usual manner of estimating the refraction, it amounted to one-fourth of the arch of distance, instead of one-twelfth, the mean quantity.

"That land was seen under these circumstances there cannot be a doubt; for it was observed to be in the same position, and under a similar form, on the 18th, 23d, 24th, and 25th July 1821, when the ship was in longitude from 12° 30′ to 11° 50′ W., and on the 23d it remained visible for twenty-four hours together; and, though often changing its appearance, by the varying influence of the refraction, it constantly preserved a uniformity of position, and general similarity of character. In my journal of this day, I find I have observed, that my doubts about the reality of the land were now entirely removed, since, with a telescope, from the mast-head 'hills, dells, patches of snow, and masses of naked rock, could be satisfactorily traced, during four-and-twenty hours successively.' This extraordinary effect of refraction, therefore, I conceive to be fully established." p. 106—108.

A thick fog prevailed the greater part of the 15th June. On the 17th the weather was perfectly clear, and the land in sight all the day. As they advanced southward, some additional headlands were discovered, and the bearings of them taken. The Latitude at noon was 73° 17′, Long. 17° 40′ W. On the 18th, an opportunity again offered of prosecuting the surveys, and some additional bays, headlands, and islands, appeared in sight, but the distance was too great for getting their accurate outline. One of these we observe named Cape Franklin, in honour of the distinguished leader of the Arctic Land Ex-

pedition, and others, in compliment to Freycinet, Humboldt, &c. The Latitude, at noon, was 73° 1′, Long. 18° 1′ W. On the 19th June the weather was calm and clear, and the sun warm and most oppressive. The sea reflected objects as accurately as a mirror, from its unruffled surface.

"The strong action of the sun's rays soon produced such an unequal density in the atmosphere, that some of the most extraordinary phenomena to which this circumstance gives rise were exhibited. The land, to appearance, was suddenly brought fifteen or twenty miles nearer to us; its boldness and clearness, as seen from the deck, being superior to what its elevation and distinctness had previously been as seen from the mast-head. The ice about the horizon assumed various singular forms:—hummocks became vertical columns,—floes and fields arose above the horizon, like cliffs of prismatic-formed spar,—and, in many places, the ice was reflected in the atmosphere at some minutes elevation above the horizon. The ships around us, consisting of eight or nine sail, presented extraordinary characters. Their sails and masts were strangely distorted. Sometimes the courses would be depressed to almost nothing; the topsails expanded to near four times their proper height, and the topgallant-sails truncated. Occasionally a very odd spectacle occurred; an additional sail appeared above the topgallant-sail, like a royal hanging loose; and sometimes the expanded topsail, divided into two distinct sails, by the separation of all the additional height given by the refraction, which, slowly rolling upward, as it were, like the lifting of a curtain, dispersed, and became invisible, after leaving the mast-head. Above some distant ships, there was an inverted image in the air, many times larger than the object itself: this, in some instances, was at a considerable elevation above the ship; but it was found to be of a less size whenever the original and the image were not in contact. The image of one ship was distinctly seen for several minutes together, though the object to which it referred was not in sight! One ship was crowned with two images; the first an inverted one, and the second, a circumstance I never before observed, in its proper position. Altogether, the shipping, and other objects around us, presented a most amusing spectacle. They were perpetually changing their appearance, and afforded me abundant entertainment for hours together. The most remarkable effect produced, was on the most distant objects, the interesting appearances of which not being discernible without the use of a telescope, probably escaped general observation." p. 117—119.

The days of June 21, 22, and 23, were employed in the active pursuit of whales, but without success; and here an interesting account is given of the loss of one of the harpooners, who got entangled in one of the lines, and was hurried from the boat into the depth of the ocean, with the velocity of a cannon ball. On the 25th a whale was harpooned. It took 960 fathoms of line from the "fast-boat," was re-struck, and killed, after an interval of three hours. On the 26th of June, the whales having left them, they proceeded to the westward in search of them, into a large clear opening, several leagues in breadth. In beating through the ice to reach the opening, irregular alternations of blue and turbid-green water were observed on every tack the ship took. In the evening, they again approached nearer to the land, being in Lat. 71° 9′, Long. 18° 48′ W., and obtained a series of bearings of the coast, and a sketch of about ninety miles of coast. On the 29th a narwal was killed, and the crew were actively employed until the 3d July, in the pursuit and killing of whales and narwals, and many curious details are given in the Journal, in regard to the habits, manners and structure of these remarkable animals. The whales having disappeared, they now cruized about in different directions amongst the ice. An immense quantity of the Little Auk flew past the ship, to the west. For many hours successively, perhaps from one to three flocks, consisting, on an average, of about two or three hundred birds, passed them in the minute, all flying in the same direction. It was calculated that near *half a million* of these birds appeared within sight in the course of twelve hours.

On the 5th, they were in Lat. 71° 7′, Long. 18° 40′ W. On the morning of the 9th, the atmosphere was in a highly refractive state, concerning which many interesting statements are given in the Journal; and the latitude, in the afternoon of this day, was 72° 10′ N. Early on the morning of the 15th July, a whale was captured, and many details are given in regard to the anatomical structure and physiology of these colossal animals. During the twenty days preceding the 15th July, about three-fourths of the time was foggy; and the facts stated in the Journal lead to an explanation of the extraordinary prevalence of foggy weather in the polar seas, and an investigation of the causes of the arctic fogs, which Captain Scoresby is inclined to consider as caused by the damp air near the level of the sea being cooled by contact with, or radiation from, the ice, which occasions a condensation of that proportion of moisture which the diminished temperature prevents the air from retaining. About midnight

of the 16th, they fell in with a large ice-field, along the edge of which they coasted for six or eight hours, and accomplished a distance of thirty or forty miles. This field could not be less than thirty miles in diameter, and probably contained a surface of 700 or 800 square miles in a single sheet! They were now in Lat. 72° 33′, Long. 19° 8′ 45″ W. The land was in sight from NNE. to NNW., and filled up the interval not before seen, and enabled Captain Scoresby to determine the general position and tendency of the coast, from Lat. 75°, down to Lat. 70°. No whales appearing, they again sailed to Lat. 71°. On the 16th, 17th, and 18th July, numerous interesting displays of atmospheric refraction were observed, for the description of which, and the ingenious speculations regarding their formation, we must refer to the Journal itself.

Their endeavours to find whales, at a distance from the coast, having failed, Captain Scoresby considered himself fully justified in approaching nearer to the shore; and, on the 19th July, they came close to the land at the mouth of a bay, in Lat. 71° 2′. On the 20th, they got within six or seven miles of the coast, which afforded an opportunity for various surveying operations. At noon, the latitude observed was 70° 44′ 57″ N., Long. 21° 9′ W. The land at this time surveyed, including fifteen miles of coast to the southward, and twenty-five to the northward, was rugged, black, and barren, and the general height of this coast about 3000 feet. On the 24th July, they again approached the land, when the sky became clear.

"Being anxious to land upon a coast, on which no navigator (a whale-fisher or two perhaps excepted) had ever set foot, I thought this a favourable opportunity for gratifying my curiosity. This curiosity was heightened almost to the utmost pitch, by the historical recollections of the Icelandic colonies, that had, at a remote period, been planted a few degrees to the southward, upon the same line of coast,—and particularly by the hope, which I could not avoid indulging, that I might be able to discover some traces of those hardy people, the fate of whom, for near four centuries, has been a problem of such intense and almost universal interest. An additional interest attached to the investigation of this country (if the interest excited by the above considerations were capable of augmentation), was the circumstance of the singular and total failure of the many attempts of the Danes to reach this coast, for the recovery of the ancient colonies,—together with the peculiar enjoyment that necessarily arose out of the conviction, that the shore on which I designed to land was entirely

unknown to Europeans, and totally unexplored." p. 183, 184.

They stood in, and landed on a rocky point, named Cape Lister, lying in Lat. 70° 30′ N., and Long. 21° 30′ W. The rugged rocks of this point were primitive, and the vegetation was confined to a few lichens, with occasional tufts of *Andromeda tetragona*, *Saxifraga oppositifolia*, *Papaver nudicaule*, and *Ranunculus nivalis*. Here the remains of Esquimaux huts were discovered, and fire-places with ashes, thus intimating, that the inhabitants may have been in this quarter within a few weeks of the time of landing. On returning to the ship, after the first landing, many curious effects of atmospheric refraction were observed. One is so interesting, and brings so strongly to our recollection the boasted powers of the *beacon-keeper* of the Isle of France, that we cannot refrain from communicating it to our readers.

" The most extraordinary effect of this state of the atmosphere, however, was the distinct inverted image of a ship in the clear sky, over the middle of the large bay or inlet before mentioned,—the ship itself being entirely beyond the horizon. Appearances of this kind I have before noticed, but the peculiarities of this were,—the perfection of the image, and the great distance of the vessel that it represented. It was so extremely well defined, that when examined with a telescope by Dollond, I could distinguish every sail, the general " rig of the ship," and its particular character; insomuch that I confidently pronounced it to be my Father's ship, the Fame, which it afterwards proved to be;—though, on comparing notes with my Father, I found that our relative position at the time gave our distance from one another very nearly thirty miles, being about seventeen miles beyond the horizon, and some leagues beyond the limit of direct vision. I was so struck by the peculiarity of the circumstance, that I mentioned it to the officer of the watch, stating my full conviction that the Fame was then cruizing in the neighbouring inlet." p. 189, 190.

On the 25th passed Cape Tobin, the southernmost headland of the coast just surveyed. About five leagues to the westward of this cape, that is further up the inlet, a new coast appeared, having a different form from any hitherto met with, and which was named Jameson's Land. The south side of the inlet is mountainous, and is terminated to the eastward by a bold narrow promontory, which was named Cape Brewster. A second landing was made at Cape Hope (so named in compliment to S. Hope, Esq. of

Everton), where a series of angles and bearings for the advancement of the survey was taken. Some whales having made their appearance, Captain Scoresby was encouraged to prolong his stay in this quarter, which afforded him an opportunity of visiting the shore, on a more insteresting spot than formerly, on the east side of Jameson's Land. The place selected for landing upon was Cape Stewart, so named in honour of Professor Dugald Stewart. The appearance of the country all around was totally different from any of the other parts of the coast already visited,—they being of primitive rocks, whilst in Jameson's Land, as far as examined, all the rocky masses were of the coal formation. The latitude, this day, was 70° 25′ N., Long. 22° 21′ 45″ W. The great inlet already mentioned was named Scoresby's Sound, in compliment to Mr. Scoresby *senior*, one of the most active and skilful navigators of the Greenland Sea; and our readers, we are sure, will do justice to the feeling and delicacy of the following remarks:

"Very little assistance was hitherto afforded me by any individual, in the investigation of these regions; but where any valuable information had been received, I considered it incumbent on me to compliment the person whose researches had been useful to me, by applying his name to the portion of land, or sea, respecting which he had supplied the information. Agreeable to this practice, I could not, without evident injustice, overlook the very important researches of my Father in this inlet,—who not only was, I had reason to believe, the original discoverer of it, but who was the first navigator who entered it, and determined its general position, and who, with a peculiar perseverance, sent his boats and examined two of its extensive ramifications, to a distance of sixty miles from the extreme capes, or entrance of the inlet. As such, after some scruples of delicacy, lest it should be considered as bordering on self-compliment, I ventured to name this capacious inlet, in honour of my Father, Scoresby's Sound." p. 196, 197.

After a description of Scoresby's Sound, we have an account of another landing on the coast of Cape Hope. Here traces of inhabitants, in the remains of huts and tumuli, resembling those before observed, were met with. Fragments of the horns of rein-deers, with human bones, and those of dogs, were collected. The skull of a dog was found in a small grave, probably that of a child, as Crantz informs us, that the Greenlanders lay a dog's head by the grave of a child, considering that, as a dog can find its way every where,

it will shew the ignorant babe the way to the land of souls. Few living creatures were to be seen, excepting insects; scarcely any birds, and the only quadruped met with was the white hare (*Lepus glacialis*). The insects were numerous, consisting of mosquitoes, and several species of butterflies. The heat amongst the rocks was oppressive, and the temperature about 70° Fahrenheit. In the account of Jameson's Land, which follows, a description is given of the fine section of the coal formation at Neill's Cliffs; and also of the numerous traces of inhabitants, some very recent, seen in the neighbouring district. One hamlet consisted of nine or ten huts. The roofs in all the huts had fallen in, or had been removed, on account of the wood of which they are composed; what remained consisted of an excavation in the ground, at the brow of a bank, about four feet in depth, fifteen feet in length, and six or nine in width. The sides of each were supported by a wall of stone, and the bottom appeared to be gravel, moss and clay. The access to these huts was a horizontal tunnel, perforating the ground, about fifteen feet in length, opening at one extremity on the side of the bank, into the external air; and, at the other, communicating with the interior of the hut. The funnel was roofed with slabs of stone and sods, and was so low, that a person must creep on hands and feet to get into the dwelling. The admirable adaptation of this kind of dwelling to the nature of the country, and the circumstances of the inhabitants, is thus described by our author:

"I was much struck by its admirable adaptation to the nature of the climate, and the circumstances of the inhabitants. The uncivilized Esquimaux, using no fires in these habitations, but only lamps, which serve both for light and for warming their victuals, require, in the severities of winter, to economise, with the greatest care, such artificial warmth as they are able to produce in their huts. For this purpose, an under-ground dwelling, defended from the penetration of the frost by a roof of moss and earth, with an additional coating of a bed of snow, and preserved from the entrance of the piercing wind, by a long subterranean tunnel, without the possibility of being annoyed by any draught of air, but what is voluntarily admitted,—forms one of the best contrivances which, considering the limited resources, and the unenlightened state of these people, could possibly have been adopted. The plan of the tunnel is ingenious. It always has its opening directed to the southward, both that the meridian rays of the spring and autumn sun may pierce it with their genial

warmth, and that the north, east, and west winds, whose severity must be most intense, may blow past without penetrating. In some cases, the bottom of the tunnel is on a level with the floor of the hut; but, in others (when there is, perhaps unwittingly, a practical application of a scientific principle) the tunnel is so much below the hut, that the roof of the former coincides with the floor of the latter. On this plan, the cold air which creeps along the tunnel, being denser than the air in the hut, can have no tendency to rise into it, but the contrary, unless a circulation were intentionally encouraged, by allowing the escape of the warm air from the windows or roof. In general, it appears, that the interchange of air must be effected by the slow and almost imperceptible currents passing and repassing in the contracted tunnel." p. 209, 210.

Adjoining the huts were remains of stores and other offices, and also many graves. Numerous pieces of rein-deer's horns were found, also bones of seals, walrusses, bears, dogs, narwals, and whales, and the thigh-bones of an animal, the species of which could not be determined. The number of inhabitants, Captain Scoresby remarks, that have, at no distant period, resided in Jameson's Land, must have been very considerable, since the remains of huts, with graves, were found all along the shore, in almost every place suitable for their erection. The vegetation in this land was considerable, the ground in some places being clothed with grass a foot in height, and here were collected *Ranunculus nivalis*, *Saxifraga cernua*, *S. nivalis*, *Eriophorum capitatum*, *Epilobium latifolium*, *Dryas octopetala*, *Papaver nudicaule*, *Rhodiola rosea*, with creeping dwarf willows, &c. A new species of mouse, allied to the Lemming, was caught; brent-geese, plovers, ptarmigans, &c. were observed; several butterflies, and some bees and mosquitoes, were collected. Captain Lloyd of the Trafalgar sailed in his boat up Hurry's Inlet, for twenty miles, along the coast of Jameson's Land, and landed on one of the promontories, where he found the heat as oppressive to his feelings as the climate in the East or West Indies. It so overcame his men, who had attempted to ascend an adjoining hill, that they could not proceed, but, lying down, fell fast asleep. The power of the sun was such, even in this high latitude, as to occasion violent inflammation of the eyes, which continued for several days. The mosquitoes, which were very numerous, likewise added to the inconvenience they suffered from the heat, by biting them with great severity. The effect of the heat on the ground was such, that

the dry turf was easily lit with a match, and afforded a ready fire.

After describing the wild and striking country, extending from Cape Brewster up Scoresby's Sound, the Journal again proceeds. The coast was next examined down as low as Lat. 69°. A little before midnight of the 29th July, the sea froze all over, though the thermometer never sank below 31° Fahr. at the height of the deck. The sky being clear, and the sun in the horizon, the effect was ascribed to radiation. A curious optical deception occurred, when the sun was just about setting, respecting the distant objects. Seeing a piece of ice at the apparent distance of two or three miles, on which there was a great load of rocks, a boat was dispatched to procure some specimens. To the surprise of the people in the boat, they rowed hard for two or three hours before they reached it, when the mass of ice that had appeared to be only a few feet high, under the erroneous idea which had been formed of its distance, proved to be higher than a ship's mast-head. On the 30th of July, being now nearly 2° of latitude farther south than the lowest parallel in which Captain Scoresby had ever pursued the whale-fishery with success, and being disappointed in his expectation of finding whales, he determined to make researches for whales in other quarters. He now, therefore, bore away to the eastward, with the view of doubling the chain of floating ice-bergs off Cape Brewster. Their number proved to be more considerable than had been expected. One of them was a mile in circumference, and 100 feet above the level of the sea, and the estimated weight of this *floating mass* was 45 millions of tons! On the 31st July, they continued their course to the north-eastward, skirting the western edge of the ice: the Lat. at noon was 70° 25′ N., Long. 19° 11′ W. An angle of the highest peak of Roscoe mountains, taken in passing them at a considerable distance, gave the height of 4370 feet,—the altitude of Ben Nevis, in Scotland. On the 6th August, in Lat. 72° 7′, Long. 19° 11′, soundings were obtained in 118 fathoms. The temperature of the sea at the surface was 34°, and, within five fathoms of the bottom, by a Six's thermometer, it was 29°. The air at this time was 42°. In all former experiments on the temperature of the Greenland Sea, Captain Scoresby invariably found it to be warmer below than at the surface,—facts which lead to some further interesting observations which we cannot spare room for noticing. The neighbouring floating ice-bergs and ice-fields offered opportunity for new observations and views in regard to their formation.

Mention is made of ice crystallized in cubes, rhomboidal dodecahedrons, rhomboids, and prisms. But here there must be some oversight: there can be but one primitive form in ice,—in this case the cube or rhomboid,—and we have no doubt that the rhomboid is the primitive form; and, therefore, that the supposed cube and rhomboidal dodecahedron would have proved, on more accurate investigation, to be forms of the rhomboidal series.

Having failed in falling in with whales, they again stood in for the land, and got close in with the shore and abreast Traill Island, (named in compliment to Dr Traill, a distinguished physician and naturalist in Liverpool). A landing was effected here, and very numerous relics of the natives were met with. On one flat of land, to the eastward of Cape Simpson, they observed several dozens of old huts, and ground-plots of summer tents. A lamp, of the kind commonly used by the Esquimaux, was picked up by one of the Trafalgar's sailors; numerous pieces of the keels of sledges were collected, intimating not only that the inhabitants had once been very numerous there, but that they must have made great use of their sledges, to afford so many pieces of these half worn defences for the keels. There were remains and bones of rein-deer, dogs, narwals, seals, bears, about the old hamlets they visited, and these in very great abundance. The vessel was nearly lost in this quarter during a violent gale. The long and tedious gale which commenced blowing NE., on the night of the 13th of August, and the rain which had fallen in an incessant and heavy shower, that lasted for sixty-two hours, at length abated. The quantity of rain that fell far exceeded any thing of the kind ever observed by Captain Scoresby. The boats were likely to be torn from the tackles, by the weight of the water that collected in them before it was observed, and after they were repeatedly emptied. The survey was continued along the coast, and various headlands, bays, and islands, noted and named. A distant tract of mountainous country was seen across the interior of Davy's Inlet (so named in honour of Sir Humphrey Davy); but it appeared to be insular. To the westward of this island, there is a chain of the most elevated mountains hitherto met with during this survey. This chain, named Werner Mountains, from respect to the memory of the celebrated geologist, is distinctly seen at the distance of between thirty and forty leagues, in the ordinary state of the atmosphere, and is so bold as to give to the mountainous coast before it the appearance of low hummocky

land. Many very beautiful and interesting haloes made their appearance, and pages 273. to 284. are occupied with descriptions of these, and speculations on their mode of formation. During the six preceding weeks, the search for whales proved almost wholly unsuccessful. The land had already assumed its winter covering of snow,—the sea began to freeze in the evenings, and the gloom of the lengthening night marked the approach of winter, and intimated that the fishing season was nearly at a close. The only hope of additional success depended on their vicinity to the coast. The resolution of remaining proved a fortunate one, for, on the 15th August, three large whales were captured.

On the night of the 15th and 16th, stars were seen for the first time during fifteen weeks; the sky became beautifully clear, the sea, as usual on such occasions, began to freeze as soon as the sun descended within 4 or 5 degrees of the horizon, though the temperature was invariably above the freezing point of sea-water, an effect which, Captain Scoresby remarks, may be ascribed to the cooling of the surface of the water, by the effect of radiation between the surface of the sea and the atmosphere. The fact of the abstraction of the heat of the water, when exposed to the full aspect of a colourless sky, is certain; but, in cloudy weather, no freezing of the sea ever takes place, when the temperature is above 29°; but, in clear and calm weather, the sea generally freezes on the decline of the sun towards the meridian below the pole, though the temperature be 32° or higher. In the instance now alluded to, the freezing commenced when the temperature was 36°, being 7½° or 8° above the freezing point of sea-water. On the 20th August the weather cleared, and allowed the survey to be continued. The Latitude at mid-day was 71° 50′ 28″, Longitude 20° 43′ 15″ W. Various headlands were named, in honour of distinguished naturalists and navigators, as Capes Brown, Krusenstern, Buch, &c. Mr. Scoresby *senior* visited his son in the afternoon of this day, and gave an account, published in the Journal, of the interesting adventures of the crews of two of his boats, who were absent nearly forty hours during the severe storm of the 12th and 13th. On the 25th August the survey was terminated. The great hazard they encountered on the storm of the 23d, with numerous symptoms of approaching winter, warned them to quit a coast which was daily becoming more and more dangerous. In the early part of this month they experienced the heat of a British summer, and numerous birds were seen,—but the land was now covered with snow,

and the birds were moving off to their southern quarters. Another intimation of approaching winter, to which they had been little accustomed in the Greenland Fishery, was the setting of the sun, and the rapid shortening of the days: On the 2d of the month it was observed that the sun was above the horizon at midnight; but now they had 7 hours 36 minutes betwixt sun-setting and sun-rising, with an increase of 10 minutes in the length of each succeeding night. Hence the shortening of the days was so rapid, as to be almost perceptible between one day and the next, without the use of a watch; added to the gloom common to the night, in the absence of the moon, the darkness was much increased by the deep and thick fog. It was therefore determined to leave the coast, and proceed homewards,—a determination which was acted upon in the evening of this day.

In the 12th chapter of the Journal, which follows, there is an interesting retrospective view of the researches made upon the eastern coast of Greenland, shewing that the extent of coast surveyed was about 800 miles. The errors of former charts are pointed out,—the general characters of the coast delineated,—and, from a comparison of the inlets on the newly discovered coast, with those on the west coast, mentioned by Sir Charles Gièsecké, it is inferred *that Greenland is probably a great group of islands.* The productions of the country are next enumerated,—and a full statement of the characters of the relics of the human inhabitants lead to the inference, that its population is Esquimaux, with an intermixture of Europeans, probably of the ancient colonies planted by the Icelanders.

"Hence, there is some reason to believe that these colonies were not entirely depopulated,—that they are not yet extinct; though it is more than probable that such of the colonists as outlived the 'black-death,' and the privation they must have suffered, when their supplies were cut off, as it is said they were, by the descent of the polar ice, would cease to be a distinct people;—for being then reduced to the necessity of following the occupation of the Esquimaux, and of copying their manners, they would probably become gradually incorporated with the aborigines, until few traces of their original civilization remained.

"The very extraordinary circumstances connected with these colonies of Icelanders, as regards their original planting,—flourishing condition,—reception of Christianity,—and their total separation from the world, since the beginning of the fifteenth century;—and the very important question re-

specting their fate, to which their early history gives rise, rendered researches for inhabitants on this coast an object to me of the most intense interest. Hence, it may readily be conceived what was the nature of my disappointment, when, on descending to the latitude of 69° 30′, where I was only at the distance of about seventy leagues from the site of the northern colonies, as given by Crantz, the main interests of my voyage obliged me to put about, and return to the northward. This disappointment was the greater, since I could observe no other hindrance to my penetration along the coast. I had reason, indeed, to believe, that, could I have been justified in devoting three or four weeks of my time entirely to research, I might have coasted the land down to Cape Farewell, and seen every station of the colonies by the way. In such an investigation I apprehended little difficulty. The chief difficulty, that of obtaining an entrance through a body of ice, 100 to 150 miles in width, which skirted and defended the coast, was already overcome; and as, in the 70th, 71st, and 72d parallels of latitude, we found the best navigation close in-shore, we had some reason to expect that we should not, at any rate, have met with any thing insurmountable to obstruct our way to the southward, even down to the extreme promontory of Greenland." p. 337—339.

We deeply regret that the nature of Captain Scoresby's engagements forced him to abandon the investigation of the country along the line of coast where the Icelandic colonies were planted. Now, however, since the way has been opened by his investigations, we trust another season will not elapse before this interesting country is examined, down to Cape Farewell, by our author himself, and also by ships sent out by the Governments of Britain and Denmark.

On the 30th August they got clear of the ice, on which occasion the following excellent remarks are given.

"It is not easy for a person, unacquainted with the navigation of the polar seas, to judge of the perpetual anxiety that the commander of a ship suffers, while involved among the crowded, extensive, and dangerous ices with which these regions abound. Among drift-ice, whenever the wind is high, ships are liable to receive blows that might be destructive; and, among fields and floes, when the weather is thick, so that the dangers of the navigation cannot always be discerned before it is too late, they are exposed to the closing of these irresistible masses of ice upon them, which are capable of crushing them in pieces in a moment. Ships under-way are almost perpetually exposed to one or other of these dangers; nor

are ships moored to the ice by any means in safety, as our experience this voyage too powerfully demonstrated. Where floes abound, they are almost continually revolving and driving about in various directions, and frequently coming into mutual contact, with tremendous concussions. Different causes operate in bringing separate masses into contact, the combined influence of which is often altogether incalculable. Thus, superficial currents, which are not uncommon, operate more powerfully upon light ice than heavy ice, so as to carry the former with greater velocity than the latter. The wind also, which acts upon all ice, and gives it a universal tendency to leeward, operates more powerfully on light and hummocky ice, than on heavy and flat ice, so that the two former descriptions drift faster than the two latter. This general tendency of the ice is modified by the influence of other ice in connexion or contact with it, also by the different forms which the sheets of ice assume, and by the position in which they lie, in reference to the wind. For instance: while circular sheets of ice, or sheets having a regular polygonal form, generally drift directly "before the wind,"—oblong pieces pursue a medium course between that of the direction of the wind, and the point to which the leeward extremity of their longest axis is directed. Hence it is evident, that the united effect of these various causes influencing 'the set of the ice,' can never be fully anticipated; although long experience, in navigating the polar seas, will enable a person of observation, in most cases, to form a tolerably correct judgment of the safety or danger of almost any situation. Such being the anxieties and dangers attendant on the navigation among the northern ices, the relief that the captains of the whalers experience, when they get clear out to sea, must be in some degree appreciated. My father has been heard to express his feelings on this subject, when fairly at sea, with the characteristic observation, that *his watch was out*." p. 349, 350.

On Sunday, September 1st, the sea was observed coloured in veins or patches, of a brown colour, or sometimes with a yellowish green; and this water, on being examined by the microscope, appeared swarming with minute marine animals. A drop of this water contained 26,500 animalcules. Hence, reckoning sixty drops to a dram, there would be a number in a gallon of water, exceeding by one-half the amount of the population of the whole globe. It affords an interesting conception of the minuteness of some tribes of animals, when we think of more than 26,000 individuals living, obtaining

subsistence, and moving perfectly at their ease in a single drop of water. " A whale," says our author, " requires a sea, an ocean to sport in; about a hundred and fifty millions of these minute creatures, would have abundant room in a tumbler of water."

On the 3d September they experienced a severe gale. On the 5th came in sight of Myngeness, the most western of the Faroe Islands. The phenomena of the clouds in the high cliffs of Kalsoe and Osteroe, lead our author into an interesting speculation in regard to the formation and suspension of clouds, which we regret our limits prevent us noticing at present. At 6 A. M. of the 9th September, they made land, which proved to be the Butt of the Lewis. The weather had a troubled aspect,—the storm rose and continued to the 11th, when it raged with great violence during the whole day. The account of the storm is one of the most interesting relations in this interesting volume. Captain Scoresby expresses strongly his feelings of gratitude, for his preservation during these terrible scenes of danger. On the 14th September, the sun exhibited a curious appearance at setting. A little before the lower limb had descended to the horizon, it became suddenly elongated downwards, in the form of a prodigious ball of fire. This appearance occurred when the sun was directly in a line with Inisterhol on the coast of Ireland, which not only eclipsed the light upon this island, but emblazoned it with the most splendid luminary of our system. In their progress southward, the arrangement of the light-houses, on different points of the coast, gave rise to some excellent remarks on the necessity of regular, systematic, and easily intelligible descriptions of them, for the use and safety of mariners.

The Baffin reached Great Orme Head on Wednesday the 18th September, and speedily afterwards Liverpool.

The Journal is succeeded by a valuable and interesting Appendix, consisting of nine different articles. No. 1. List of Specimens of Rocks brought from the Eastern coast of Greenland, with geognostical remarks by Professor Jameson. No. 2. List of Plants, from the East Coast of Greenland, with some remarks by Dr Hooker, Professor of Botany, Glasgow. No. 3. List of Animals met with on the Eastern Coast of West Greenland, with notes and memoranda, by Professor Jameson and Dr Traill. No. 4. Meteorological Table, including the daily latitude and longitude of the ship. No. 5. Journal of Proceedings on board of the Hercules of Aberdeen, on the Coast of Greenland. This journal is valuable

to the whale-fisher. It gives an account of the capture of whales at a very late season of the year, and includes some important observations on the dangerous nature of the East Coast of West Greenland, as a fishing-station, at the end of summer. It also includes an account of the sufferings by some of the crew of the ship King George.

"The crew of the King George, it appears, struck a fish during one of those severe gales which we had in the month of May, when the thermometer fell to zero or below. Thick weather setting in, the boats lost sight of the ship, and were exposed to the severities of the most intense cold and violent storm, for fifty hours. One man fell a victim to the cold while on the ice, and another died soon after he reached the ship. All of them suffered from the severity of the exposure more or less. Some lost their fingers,—others their toes,—some their hands,—and others their feet. The surgeon of the King George told Mr Gibson, surgeon of the Trafalgar, who supplied him with some dressings, that he had amputated thirty-five fingers and toes in one day! An example was given of the severity of the cold, by one of the King George's sailors, who stated, that a quantity of beef that was sent in the boats to the men upon the ice, when they first saw them, was taken hot out of the coppers; but before they reached the ice, though at no great distance, it was frozen so hard, that they had to cut it in pieces with hatchets." p. 451, 452.

No. 6. Journal of Proceedings on board of the Trafalgar of Hull, on the East Coast of Greenland, from the 12th to the 31st of August 1822. Besides many valuable details, this Journal contains the following very striking instance of escape from the dreadful perils of the ice. The crew of the Trafalgar, in the midst of appalling dangers, made various attempts to moor the ship to the ice. It was in an attempt of this kind that the interesting incident and escape took place, which is thus related in the journal.

"At 9 P. M. we made another attempt to moor the ship to a floe or field of ice. Five active men were sent to fix some anchors, and two warps were fastened to them. Two of the men in the boat returned for another anchor, and just as they got hold of the ship, both the warps broke that were fast to the ice; and the ship turning quickly round, received a dreadful shock on her quarter against the floe. This compelled us to stand out amongst the loose ice again; about an hour afterwards we returned, and sent a boat to endeavour to bring on board those unfortunately left on the ice. But the

sea was so heavy that the men refused to risk themselves in the boat, and it returned without them. We now were obliged to reach off to the eastward, among the loose ice, to the distance of nearly twenty miles from the poor men on the floe. Here we had room to beat to windward. At midnight the wind veered to the eastward, and began to abate.

"*Saturday*, 24*th*.—Towards morning the weather cleared up, and the wind abated, on which we commenced a careful search for the five absent men, though with very small hopes of ever seeing them again. But, after standing four hours to the westward, to our great joy, we got sight of them with the glass from the mast-head, upon a small piece of ice, and at 8½ A. M. sent a boat and took all of them on board alive; and, considering the severities they had endured from cold, wet, and hunger, in better health than possibly could have been expected. The same hardships must have killed any one not accustomed to these regions. It was indeed a deliverance of the most extraordinary description. The account they gave of their perilous adventures, was to the following effect:

"Shortly after the departure of the boat which had attempted their rescue, a portion of the floe upon which they stood broke off by the action of the swell, and before they could step across to the main sheet, the water intervened and prevented their retreat. They soon drifted from beneath the shelter of the floe into a heavy sea. Almost every other wave now washed over the piece of ice, so that, to secure themselves, they were obliged to lie down flat on their bellies, and cling to the edge of the ice with their hands. In this state of dreadful suffering and danger, they remained until about midnight, when the mass of ice to which they clung was dashed by the waves against another lump, and broke into three pieces. They were fortunately on the largest part (which, however, was only a few yards in diameter), and on this they spent a dismal and hopeless night, frequently washed over by the sea, and in perpetual expectation that the next heavy wave would force them from their imperfect hold, and bury them in the deep. As soon as the sea began to fall, they contrived to stand upright, and to move about, so as to gain a little warmth. But this measure was likely to fail, when, on the clearing away of the mist, they were overwhelmed in despair, on finding there was no ship within sight. The Trafalgar, they now apprehended, had foundered in the gale, and if so, their situation was indeed without hope. The usual effect of severe exposure, in occasioning drowsiness, then began to make its appearance

amongst them, and one man expressed great desire to sleep, which, however, his companions very prudently prevented: otherwise, it is probable, he would have awoke no more. Soon afterwards they were rejoiced by a sight of the ship, whose approach gave some stimulus to their spirits, and enabled them to make that exertion which was necessary for preserving life, until they could be taken from their perilous situation." p. 459—461.

No. 7. is a Table of Latitude and Longitude of Headlands, Bays and Islands on the East Coast of West Greenland. No. 8. Remarks on the Structure of Greenland by Sir Charles Gièsecké, in which it is said, and in confirmation of Captain Scoresby's view, "That the whole coast of Greenland formerly consisted of large islands, which are now, as it were, cemented together, by immense masses of ice." And No. 9. contains useful explanations of some of the Technical Terms made use of in the course of the work.

Such, then, are the general contents of this very amusing, and highly interesting volume. The concluding general observations we had to offer on the value of the discoveries here communicated to the world, both in a commercial and scientific view, must be delayed for the present, as we have already much exceeded the limits prescribed for our article. We trust, however, that the rapid view of the Journal contained in the preceding pages, will convey to our readers an adequate idea of its nature; and as we have made Capt. Scoresby describe the natural phenomena he witnessed, and state the speculations they gave rise to, and the difficulties and dangers he experienced, in his *own words*, we feel confident, that we do him perfect justice, and afford much more satisfactory and useful information to the public, than if we adopted the practice of throwing the author into the shade, by intruding our views and fancies in place of his facts and reasonings.

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ART. XXVIII.—*A new and easy method of ascertaining the degree of Temperature at which Water is at its Maximum Density.* By MR JAMES CRICHTON.

(Annals of Philosophy.)

—Having lately been engaged in determining the specific gravities of certain fluids, by means of adjusted balls of

glass, and being satisfied that for simplicity and accuracy, no method whatever is nearly so good; I was led to think, that another important point could thereby with greater certainty be ascertained, than by any mode yet adopted. This is to determine the temperature at which water attains its maximum density.

Of all who have hitherto attempted to decide this question, whether British or foreign philosphers, no one seems to speak with the precision which might be desirable, of the degree at which the phenomenon takes place. The French say it is between 4 and 5 of Celsius, thus admitting an uncertainty of about 2° of Fahrenheit; some in our own country think it is at 39, while others place it at 40.

Any person who is aware of the many sources of error, and of the vague nature of the requisite compensations, will not wonder at this indecision; the difficulty alone, of maintaining an uniform temperature, throughout a large or deep body of water is very considerable; hence the bulkiness of the solid used by the French for this purpose, having been a cylinder nine inches in diameter, and of the same height, must have rendered it a matter of uncommon difficulty in the quantity of water necessary. Whether this uniformity existed, at the moment of its greatest apparent gravity, may admit of some doubt, however carefully and constantly the thermometer may have been observed; besides, air-bubbles, which it would be almost impossible to see or remove, might have considerably increased the buoyancy of the suspended solid. To estimate the compensations for expansion, in the above-mentioned method, is perplexing, and for the mode by the weighing bottle is still more so; but to ascertain the quantity of hygrometric humidity, which profusely and rapidly fixes on the exterior surface of a bottle, at so low a temperature as 40, is perhaps from several causes impracticable. A hope of being able to assist in obviating these embarrassments, induces me to present a new method of determining this point.

Having frequently observed that a very small alteration of temperature in a fluid, destroyed the precise poise of a solid in that fluid, and that an extremely minute increase or diminution of gravity in the solid, has a similar effect; it was easy to perceive, that if water is of a certain gravity just above freezing, and that if it become heavier, with an increase of temperature, before it reach, say for example, 50, then it is manifest, that at *some* included degree, water must of necessity poise, or sustain, a ball or solid of greater spe-

cific gravity, than it will do at any other point in the supposed interval.

My first attempt to ascertain this point, evinced that a ball which was just poised, at about 33, had the same property near 51; this gave 42 for the point of greatest density, taking the half of the intervening degrees as additive to 33, or the reverse from 51, since all authorities seem to agree, that the expansion is the same for equal intervals of temperature, on both sides of the maximum.

It may be supposed, that to adapt a ball of the greatest possible specific gravity which water can sustain at *its* greatest gravity, would be the next endeavour; it was, but so infinitely little is the variation of the gravity of water, for about a half degree on either side of the maximum point, that although I have, more than once, diminished the gravity of balls which were too heavy, by a quantity so minute, as not to amount to the 6000th part of a grain, or just as little as I could by any means grind off, still, on trial at the proper range of temperatures, it was found that the mark had always been overshot. This then was relinquished as a hopeless task.

As it had not however escaped notice in the course of these experiments, that the further the temperature of water was removed from that of the greatest gravity, the ball rose, or fell, with celerity just commensurate to the number of degrees which the existing temperature was above, or below, that of the desiderated degree: this, therefore, affords some idea of the approach to, or retrocession from, the temperature in question; but there is a better, and perhaps conclusive proof of its place in the scale, which I shall now describe.

I took a glass jar, 2 inches in diameter, and 3½ in depth; into this was put distilled water to the depth of 2½ inches, and cooled down to near the freezing point, but carefully prevented from congealing, as the disengagement of air-bubbles from the ice, when fluidity took place, would have frustrated the experiment; into this was put a ball, previously well wiped with a silken* cloth, and immediately, by means of a clean hook of glass, lifted, but not rapidly, twice or thrice out of the water; this cleared it of any air-bubbles, which though imperceptible, might have been adhering to its surface. The ball now fell to the bottom of the jar, which

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* In an experiment of such delicacy, this must be attended to, as linen never fails to leave fibres on whatever is wiped with it; these will detain air enough to render the efforts of the experimenter in this case abortive.

as usual was convex, but had a small flat surface on the summit, to which the ball was led, and there it rested. In the water there were suspended two very accurate and sensible thermometers, the bulbs being at the middle of the water as to depth, and just so far removed from its diametrical centre, as not to be in the path of the ball when it rose.

In these circumstances, the lower end of the ball was carefully watched with a large reading glass, and at the moment of its quitting the bottom of the jar, the thermometers were examined, and the degree noted; when the ball had risen about one-fourth of an inch, a small rod was cautiously let down, and, without agitating the water, gently made to touch the ball; it of course descended, but instantly rose; this is a very delicate part of the experiment, and if overdone loses its effect. It was frequently repeated, and the ball always reascended with accelerated velocity.

The thermometers indicating an increasing temperature, the ball finally became stationary at the surface of the water; from time to time it was slightly touched as before, but in proportion as the temperature rose beyond a certain point, the tendency of the ball to ascend, after these strokes, obviously diminished, judging by the velocity with which it did so; its upper extremity, when examined with the magnifier, plainly seemed to press as it were more and more feebly on the surface of the water, till at last, a fine thread of separation became visible; the degree by the thermometers was again marked, and as they continued slowly to rise, the ball gradually fell to the bottom of the jar.

From many similar experiments I have concluded that 42 is extremely near the true point of the greatest density of water; my most satisfactory trials never gave three-tenths of a degree less nor more, but at present, I am rather inclined to place it a very little above 42; a trial I made in very favourable circumstances a few days ago, gave for the first appearance of the rising of a ball 37-5, and for that of its sinking 46-3, these make the point in question 41-9; the local temperature was 46-8, but the barometer having been at only 29-4, the above 41-9 may be held perhaps too low. These experiments were made with balls adapted to all the intervals from 33-51 to 39-45, yielding however great uniformity of results.

As I cannot anticipate what objections, or if any, can be made to this method of ascertaining a curious and not unimportant point, I shall allude to one only; that is error from expansion of the ball, and consequent increase of its

volume; but as the whole range required does not exceed 4° or 5°, on either side of a starting point, and though it were granted that the expansion of glass is the same for 4° about temperature 42, as it is for 180°, that is from freezing to boiling of water, as determined by M. de Luc and others, the expansion for these 4° must be so extremely little, as not by any means to affect the decision in any considerable part of a degree.

But were the expansion of glass in the above range even ten times what it is, still it must in effect be cancelled, for taking 42 as the point where this expansion in the present case must be assumed as incipient, and granting that at, say 33, a ball just held in poise has become less, that is *heavier* specificially, some degree *above* 33, for example 34, where water is denser, must really be what the ball virtually indicates; again, if at 51 the same ball poises, then by a parity of reasoning the ball is now said to be increased in volume beyond what it was at 42, or it is too *light*, therefore it must indicate too high a degree, or it *really* shows that the ball, supposing it inexpansible, would have stood at a *lower* degree or denser medium, which call for instance 50; so that by the one extreme thus correcting the other, the conclusion to be drawn is the same as in the case of altogether neglecting the expansion.

The low temperature of the atmosphere when these experiments were made, gave confidence that no current upward or downward moved the water; besides, a few very minute particles of dust, just visible in different parts of it, remained entirely motionless during the whole operation.

My first trials on this subject were made with spherical balls, half an inch in diameter, having a depending stalk of about an equal length; but to obviate the possibility of error from dissimilarity of the extremities, I latterly used solids resembling in shape a buoy or parabolic spindle, sharp at the ends, of about an inch in length and 4-10ths in diameter. This shape gave another apparent advantage, that is of meeting less resistance than a sphere when moving in a fluid, and in order to ensure perpendicularity of the axis, before such a ball was hermetically sealed, a small globule of mercury was introduced, which perfectly answers that purpose.

As the momentum of an ascending ball is very apt to cause its upper extremity to rise above the water, and however free of any thing unctuous, it will there remain too

long, a slight tap or blow by a small hammer, on the under side of the table, will obviate this incident.

In cooling water for such experiments, it ought to be kept as still as possible; agitation to procure uniformity of temperature has a bad effect by charging it with air; bubbles may settle on the ball during the experiment, and must be closely watched for, as their effect may be apprehended, if detected occasionally rising through the water. Knowing the degrees at which a ball might be expected to rise or fall, I have frequently lifted it to the surface of the water a short time before, in order to free it of any thing which though imperceptible might have affected its gravity. The thermometers were sometimes placed one at the top, and the other at the bottom of the vessel, in order to ascertain, beyond doubt, the temperatures at the initial points, or the extremes of the above-mentioned intervals.

When it was considered how uncertain the indications might have been, had I succeeded in adjusting a ball to seeming equilibrium at the maximum gravity, owing to the minute variations near that point, there was little cause for regretting my failure, especially when the method by varied extents of intervals seems so satisfactory; still, since writing the above, another effort was made, when the following appearances took place.

Water in the jar being near 42, and the ball as seen by the naked eye in apparent equilibrio, it was observed with the reading-glass as seen over a slight scratch on the side of the jar. It was then very slowly descending; having two or three times breathed on the part of the jar nearest the ball, the consequent dimness was removed by a camel hair brush, but before this could be done and the eye-glass applied, the ball had decidedly begun to ascend, which it continued to do for a few seconds, and after a momentary pause again began to fall. This was repeated several times, the thermometer meanwhile ranging from 42 to 42·6; from this and other circumstances, I with due deference incline to think, that 42·3 is very near the true point in the scale of temperature, where the maximum density of water takes place. In this last trial it may not be improper to mention, that the increment of weight producing the approximating effect, was a mere speck of leaf gold, attached to the side of the ball by means of spirit-varnish, and fixed by applying a moderate heat.

Having thus given an explicit account of these experiments, apology on my part for having too minutely done so,

will be deemed quite unnecessary by any one who repeats them. I shall only add, that the thermometers having been made purposely for the experiment, I have perfect reliance on their indications. The smallness of the apparatus and its extreme simplicity, render the determination of the point wherever it is to be placed, a very plain matter. This I submit to those who are capable of availing themselves of the means it affords, and who are qualified for appreciating its powers.

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ART. XXIX.—*Notice of Messrs. Conybeare and Phillips' Outlines of the Geology of England and Wales.*—Part 1st. London, 1822.—[*J. W. W.*]

THIS publication may be considered an elaborate compilation, and condensation of all the most important papers on the Geology of England and Wales, which, from time to time, have appeared in the Transactions of the Geological Society of London*, in the scientific Journals, and in distinct treatises, together with the results of the persevering labors of the authors themselves.

The work of Messrs. Conybeare and Phillips is not less interesting to the students of Geology in this country, than to those in Great Britain. It will be found valuable to all who are desirous of acquiring a general knowledge of the structure of the crust of the earth, and of the arrangement of the rocks and strata composing it. We should be unable to do justice to this work by attempting an analysis of its minute details; but as one of the principal objects of our Journal is to present its readers with notices of valuable European publications on scientific subjects, we shall make

* The establishment of the Geological Society of London in the year 1807, gave a new impulse to the efforts of the geologists of Great Britain, and the papers which have been given to the public in the Transactions of the Society, bear abundant testimony to the zeal and industry of its members. There are few districts in Great Britain the geology of which has not been examined and described. We trust that equal attention to the physical structure of this country will be excited by the establishment of the American Geological Society, that equal success will attend the efforts of its members, and that a volume of Transactions will soon be given to the public.

such extracts as will enable those who have not access to the work to form some idea of its value.

The introduction appears to have been written by the Rev. W. D. Conybeare, and contains an elementary view of the general principles of the science of Geology, which are illustrated in the body of the work by a particular reference to the geological structure of Great Britain. The relations of the English formations to those of the continent of Europe, and the regular and connected account of the coal formations of Great Britain, are considered by the authors as among the most original and useful portions of the work.

The first part (or volume) comprises a description of the formations, commencing with the most recent, those above the chalk, and terminating with that of the lowest rocks of the coal districts. In the second part (not yet published), it is the intention of the authors to describe the primitive and transition series of rocks, and in the appendix to give a sketch of the processes connected with the working the different mines, and the metallurgical operations prosecuted in the mining districts.

The introduction commences with some observations on the simplicity of the chemical and mineralogical constitution of rock formations, and on the necessity of a competent knowledge of mineralogy to enable the student to understand their constitution analytically.

The regular order of succession in the mineral masses is thus described. "If we suppose an intelligent traveller taking his departure from our metropolis, to make from that point several successive journies to various parts of the island, for instance to South Wales, or to North Wales, or to Cumberland, or to Northumberland; he cannot fail to notice (if he pays any attention to the physical geography of the country through which he passes) that before he arrives at the districts in which coal is found, he will first pass a tract of clay and sand; then another of chalk; that he will next observe numerous quarries of the calcareous freestone employed in architecture; that he will afterwards pass a broad zone of red marly sand; and beyond this will find himself in the midst of coal mines and iron furnaces. This order he will find to be invariably the same, whichever of the routes above indicated he pursues; and if he proceeds further, he will perceive that near the limits of the coalfields he will generally observe hills of the same kind of compact lime-stone, affording grey and dark marbles, and

abounding in mines of lead and zinc; and at a yet greater distance, mountainous tracts in which roofing slate abounds, and the mines are yet more valuable; and lastly, he will often find, surrounded by these slaty tracts, central groups of granitic rocks.

"The intelligent inquirer, when he has once generalized these observations, can scarcely fail to conclude that such coincidences cannot be casual; but that they indicate a regular succession and order in the arrangement of the mineral masses constituting the earth's surface; and he must at once perceive that, supposing such an order to exist, it must be of the highest importance to economical as well as scientific objects, to trace and ascertain it.

"If with these views he is led to investigate the subject still further, he will find these mineral masses disposed for the most part in stratified beds, not exactly parallel to the horizon, but more or less inclined with reference to that plane; so that the edges of these beds, emerging in succession from beneath each other, make their appearance one after the other on the surface. It is obvious that by this arrangement a much greater thickness of strata is exposed to our observation than could have been, had their planes preserved an horizontal direction; for in that case one single stratum would have covered the planes of a medium elevation throughout extensive districts (if not the whole globe,) and we could have been acquainted with those above it only by the structure of mountains rising above that level, and with those beneath it only by the natural excavations of the vallies, or artificial ones of wells and mines; but by the actual arrangement, the beds which in one point lie at an impenetrable depth, are in others brought up to the surface, and thus become subject to our examination, and (which is much more important) yield us those various mineral products which are often essential to the most necessary of human arts."

The disposition of rocks in strata, and their arrangement into formations and general classes, are explained in a distinct and satisfactory manner. A comprehensive sketch is taken of the mode of occurrence of animal and vegetable remains, and of beds derived from the debris of older rocks, among those of more recent origin. These consolidated gravel-beds, or conglomerates, pudding-stones, and breccias, are found among the transition rocks and in the newer formations. They are composed of the fragments of older rocks, presenting every appearance of having been torn from the

previously consolidated masses, by mechanical violence (probably the action of agitated waters,) which also rounded the fragments by attrition before the formation of the rock in which they are now seen. Where the beds of these conglomerates, as is not unfrequently the case, are in nearly vertical strata, the opinion of Mr Conybeare coincides with that of most geologists of the present day, that they have been brought into their present position by the operation of some force which convulsed and displaced them.

Mr Conybeare proceeds to consider the change of level of the surface of the earth, indicated by the occurrence of animal and vegetable remains, and of the beds just noticed. He remarks that the great and fundamental problem of theoretical geology is to assign adequate causes for the change of level which has taken place in the ocean that covered the loftiest summits of the Pyrenees, and still more elevated points of the Andes, where the remains of marine animals have lately been noticed. The causes assigned are reducible to two classes, first "the decrease of the absolute quantity of water" effected by the operation of chymical laws, namely "the decomposition of some portion of the water, its constituents entering into new forms of combination, and its fixation in the rocks formed beneath it."—"The second class of possible causes is entirely mechanical; those, namely, which may have produced a change of relative level without any diminution of absolute quantity in the waters. The causes of this kind which have been proposed, are, first, the absorption of the waters into a supposed central cavity, but the now ascertained density of the earth (being greater than that which would result from an entirely solid sphere of equal magnitude, of the most compact known rock) renders the existence of any such cavity very doubtful; secondly, a writer in the Journal of the Royal Institution (Vol. 2.) has proposed the very ingenious hypothesis that a change of temperature of a few degrees will, from the unequal expansibility of the materials of land and water, sufficiently account for this change of level; thirdly, it has been ascribed to violent convulsions which have either heaved up the present continents, or, which amounts to the same thing (as the same relative change must have taken place in either view,) depressed the present channel of the ocean. It is not the business of the present work to propose theories, but to record facts; these facts are thus connected with the above discussion. If the violent elevation of the continents (or de-

pression of the channel of the ocean,) supposed in the last mentioned hypothesis, really took place, it must have left traces in the disturbed, contorted, and highly inclined position of the strata, and these disturbances must be the greatest where the change of level has been the greatest, i. e. in the neighbourhood of the loftiest mountains."

Some of the facts which have been observed in regard to the vertical position of the strata of the conglomerates, limestones, and some other rocks, and the remarkable dislocations of the strata, called faults, it is considered absurd to attribute to the action of any crystallizing force, or any cause of the kind. "No such causes could have placed a vertical bed of limestone containing encrinites, in contact with a vertical bed of coal-shale containing canes and fern leaves." As respects the vertical or inclined position of the recomposed beds, it is conceived that this cannot have been original, but must have resulted from subsequent disturbance, as it is physically impossible to support an aggregation of loose gravel in vertical, or nearly vertical, planes. These and many similar arguments will be found to apply to a large class of highly inclined strata.

The phenomena exhibited by the trap rocks are also connected with this subject, and afford many facts in favour of the hypothesis which ascribes the great change of the ocean's level to violent convulsions. Without pronouncing any judgment on the question regarding the origin of these rocks, Mr Conybeare remarks, "that the weight of geological authorities decidedly preponderates, at present, in favour of their igneous origin."

The remarks on the appearances exhibited by the numerous vallies which furrow the earth's surface, are highly interesting. The observer will first remark their regular configuration, where they serve as channels which drain the countries they traverse, conveying their waters to "their final receptacle, and at the same time their principal source, the ocean." Numerous branches, ramifying over extensive tracts of country, are collected into a principal trunk, opening into some æstuary, and a regular and continuous descent is preserved throughout the whole course, calculated to facilitate the passage of the waters through the whole system. "Now this configuration is exactly that which would necessarily be produced by the action of waters scooping out channels for their passage in draining themselves off from the face of a country. We may daily see the same operation repeated in miniature by the drainage of the retiring

tide on muddy shores, especially in confined æstuaries, where the fall is considerable and rapid." That the inequalities which now mark the earth's surface, have been in a great measure produced by an agency of this kind, "giving rise to all the beautiful variety of hill and valley, phenomena of the most decisive character, constituting a body of evidence as nearly approximating to demonstration as the nature of the case can admit, leave no reasonable ground to doubt."

On this subject many theories have been advanced which are considered defective in two points. "First, because, ascribing every thing in the formation of vallies to the agency of running waters, they entirely overlook the effect which must have been produced by the violent convulsions which appear in so many instances to have broken and elevated the strata, and must in so doing have necessarily formed a surface diversified by many and great inequalities."—The second defect is "that while they correctly ascribe the excavation of vallies to the agency of aqueous currents, they look to no other supply of that agency than the streams (often inconsiderable rills) which now flow through them, borrowing liberally from time what they confessedly want in force." Mr Conybeare conceives, that this hypothesis must be abandoned at once on the rigorous application of it to the vallies of any extensive district; and that a cause so manifestly inadequate should ever have been embraced, is the more extraordinary, "since the fundamental fact of geology, namely, that the continents, now dry land, were once covered with the ocean, which is of necessity (however differently explained) common to every geological theory, involves in itself the admission of a cause fully adequate: for however that ocean may have been brought to its present level, it could never (on any view of the matter) have drained off the surface of the lands it has deserted, without experiencing violent currents in its retreat; and in those currents (the existence of which no one can on any hypothesis dispute) might have been found a force far more commensurate to the effects to be accounted for."

In examining the phenomena on which the proofs of the agency of great aqueous currents in the formation of vallies depend, Mr Conybeare commences with those which shew that they have been excavated in the strata subsequently to their original consolidation. The nature of these proofs is illustrated by a diagram representing the sectional profile of a country composed of stratified rocks and traversed by

several vallies. If we examine the structure of these vallies "we find precisely the same series of strata repeated on both their sides, in exactly the same order, and under circumstances which indicate them to have been once continuous, and to have been subsequently removed from the intervals occupied by the vallies, by some cause which has here excavated or scooped away the materials which once filled those intervals. The phenomena are exactly similar, on the large scale, to those which would be exhibited in the small by a block of laminated marble in which the tool of the sculptor had chiselled out deep furrows; and as we should not doubt in the latter instance that the laminæ now interrupted by these furrows had been once continuous, and the interruptions effected by subsequent violence, so we have the same or stronger evidence in the case before us; for the strata broken through by the vallies are, in a majority of instances, evidently the result of aqueous deposition; now we cannot possibly suppose that such a cause could have deposited exactly the same beds, in the same order, and the same planes, throughout the mass of the hills, and yet have abruptly ceased to deposit them in the narrow intervals now possessed by the vallies; undoubtedly then those intervals were once filled by the same deposits whose truncated edges now appear on their sides; and the intervals themselves (i. e. the vallies) have been formed by the subsequent excavation or erosion of the strata in these points.

" In the treatise on the Deluge by Mr Catcot (a physico-theological writer of the last century belonging to the Hutchinsonian school) are the following forcible remarks on this subject.

" If a person were to see the broken walls of a palace or castle that had been in part demolished, he would trace the lines in which the walls had been carried, and in thought, fill up the breaches, and reunite the whole. In the same manner when we view the naked ends or broken edges of strata on one side of a valley, and compare them with their correspondent ends on the other, we cannot but perceive that the intermediate space was once filled up, and the strata continued from mountain to mountain."

" The proof, as above stated, is still further strengthened by the occurrence of broken fragments of the materials which once filled up these intervals, scattered over their surface. Not only do we observe these natural breaches bearing every mark of the violence which has produced them, but we find the ruins themselves strewn around; immense

accumulations of debris torn from the adjacent rocks, and generally more or less rounded (as if by attrition against one another while rolled along by the action of strong currents,) very generally cover the bottom of the vallies which traverse, and the plains which stretch beyond the base of the elevated chains."

Although these effects may safely be attributed to running water, Mr Conybeare remarks that the agency of the streams which now flow through vallies, is quite inadequate to have produced the appearances observed. Among other proofs of this we find one of great weight, in a phenomenon of common occurrence, "the intersection of two series of vallies, the one extending longitudinally along the base of a chain of hills, and the other cutting transversely across that chain, under such circumstances that no stream could have risen to a sufficient height to form the transverse vallies by excavating a passage through the crest of the chain, but must have discharged its waters at a level far inferior to that required for this effect, through the longitudinal valley at its base."

"The same agency that has excavated the vallies, appears also to have swept off the superior strata from extensive tracts which they once covered; the proofs of this are to be found in insulated hills, or *outliers* of those strata placed at considerable distances from their continuous range, with which they have every appearance of having been once connected; in the abrupt and truncated escarpments which form the usual terminations of the strata; and in the very great quantity of their debris scattered frequently over tracts far distant from those where they still exist in situ. This stripping off the superstrata is appropriately termed *denudation*."

The denuding causes are supposed to have operated more than once, and even "while many of the more recent beds were as yet only in the process of being deposited," for many of these beds are made up of water-worn debris "which must have resulted from causes of this kind."—"But the most important agency of this kind appears to have been exerted at a more recent period, and subsequently to the consolidation of all the strata, by an inundation which must have swept over them universally, and covered the whole surface with their debris indiscriminately thrown together, forming the last great geological change to which the surface of our planet appears to have been exposed.

"To this general covering of water-worn debris derived

from all the strata, the name *Diluvium* has been given from the consideration of that great and universal catastrophe to which it seems most properly assignable. By this name it is intended to distinguish it from the partial debris occasioned by causes still in operation; such as the slight wear produced by the present rivers, the more violent action of torrents, &c. &c.; to the latter the name *Alluvium* has lately been appropriated; but many authors confound the two classes of phenomena together, describing them generally as alluvial. The phenomena of the diluvial debris, or gravel, are highly important and interesting. Its existence, as we have already seen, demonstrates the nature of the causes which have modified the present surface of our planet; its quantity may serve in some degree as a measure of the force with which they have acted; and its distribution may indicate the direction in which the currents swept it onwards. For instance, when we find rounded pebbles derived from rocks which exist in situ only in the mountains of the north and west, scattered over the plains of the midland counties, we may be sure that the currents drifted from the former point to the latter; and it often affords a curious and interesting problem to the geologist to trace these travelled fragments to their native masses, often hundreds of miles distant."

The occurrence of rolled masses of rock of great size, at a distance from their parent strata, as the colossal blocks of granite and other primitive rocks scattered over the calcareous and secondary chains of the Jura, and over the plains of northern Germany, is familiar to every geologist. In the first instance the fragments appear to have been derived from the primitive chains of the Alps, and in the second from the Scandinavian chains on the opposite side of the great gulf occupied by the Baltic. It has been supposed that these blocks may have been transported upon ice-bergs, but this explanation is by no means satisfactory. Mr Conybeare supposes "that these fragments were transported by the first action of the currents, before they had effected the excavation of the vallies now cutting off all communication with the native rocks whence they were derived."

The organic remains dispersed through the diluvial gravel, are to be referred to the races of animals which became extinct by the great convulsion that formed the gravel. And to the same period are to be ascribed the bones found in many caverns, as in the remarkable instance of the cavern

in Yorkshire, described by Professor Buckland.* Mr Conybeare proceeds to examine "the local changes which have taken place subsequently to this last great and general convulsion, and which still continue to take place under the influence of the order of causes at present in actual operation." These causes are, the agency of the sea, and of rivers, those which are to be viewed as atmospheric, the eruptions of volcanoes, and the minute but combined labours of the millions of marine zoophytes producing coral reefs and islets.

Having thus taken a general survey of the phenomena which it is the object of Geology to investigate, Mr Conybeare gives an interesting view of the progress of the science, particularly in Great Britain.

The remainder of the introduction is devoted to an examination of the bearings of physical science on natural and revealed religion, and in conclusion it is remarked "that the evidences of Natural Religion are still further confirmed by the discoveries of Geology, as indeed could not fail to be the case; for every effort that has carried forward the landmarks of human knowledge, has at the same time disclosed to our view a widening range of this proof, and such is its cumulative nature that it regularly grows with the growth and strengthens with the strength of true science." Of the physical facts recorded in the inspired writings, two only are considered as implicated in the discussions of Geology, viz. the Noachian Deluge and the Antiquity of the Earth.

"With regard to the first of these points, Geology far from affording the slightest ground to question the truth of the Mosaic record, brings to its support (if that which rests securely on its more appropriate ground—a solid and immoveable foundation of moral evidence—can be said to require or receive much additional support from physical arguments) a strong collateral testimony. 'The grand fact of an universal deluge,' remarks Cuvier, 'at no very remote period is proved on grounds so decisive and incontrovertible, that, had we never heard of such an event from Scripture, or any other authority, Geology of itself must have called in the assistance of some such catastrophe, to explain the phenomena of diluvian action, which are universally presented to us, and which are unintelligible without recourse

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* See Bost. Jour. page 74.

to a deluge exerting its ravages at a period not more ancient than that announced in the Book of Genesis."

In regard to the second point, it has been objected, "to the authority of the sacred record, that it does not allow a sufficient period for the successive deposition of the secondary strata, containing as they do the remains of successive races of animals, which appear to have lived and died where they are now found, while the deposits in which they are buried were gradually accumulating."

An essential feature of revelation is the antiquity of the human race, but what state of our planet preceded that in which it became the habitation of human beings, and what convulsions may have happened during that state, are points, observes Mr Conybeare, with which it has no direct connexion. The conclusions, in regard to the antiquity of the human race, deducible from geological reasoning, strictly accord "with the declarations of Revelation, no human remains having yet been found excepting in beds of undoubtedly very little antiquity."

With regard to the time required for the formation of the secondary strata, we are offered the choice of three hypotheses.

"1st. If we adhere to the common interpretation of the periods of creation as having been literally days of twenty-four hours, and refuse to admit the existence of another order of things previous to that recorded by the inspired writer, we might still perhaps find a sufficient space of time for the purposes required in the interval between the creation as thus limited, and the deluge. Upon this hypothesis we must suppose the present continents (in the greater part of their extent) to have been included in the channel of the primitive ocean, and to have gradually emerged thence during this period, becoming occupied, as they appeared, by the land animals whose remains we find among the diluvial gravel; the primitive continents may upon this supposition either have been limited portions of the present, (such as present no secondary rocks,) for at first it seems evident that a limited space only would be requisite; or if more extensive, they may have been submerged in whole or in part, during those great convulsions which accompanied the deluge."

On the second hypothesis we may regard the periods of creation expressed by the inspired writer under the term days "not to have designated ordinary days of twenty-four hours, but periods of definite but considerable length;" and

to these *Days of Creation* the formation of the secondary strata may be assigned.

Thirdly, it may be supposed that after the original formation of all things there may have been an intermediate state from the ruins of which "the present order of our portion of the universe" may have been educed.

We shall conclude the notice of this valuable work with the synoptical and comparative view of the arrangement adopted by Messrs Conybeare and Phillips, and that of former writers.

<table>
<tr><th>Character.</th><th>Proposed names.</th><th>Wernerian names.</th><th>Other writers.</th></tr>
<tr><td>1. Formations (chiefly of sand and clay) above the chalk.</td><td>Superior order.</td><td>Newest flœtz class.</td><td>Tertiary class.</td></tr>
<tr><td>2. Comprising<br>a. Chalk.<br>b. Sands and clays beneath the chalk.<br>c. Calcareous freestone (oolites) and argillaceous beds.<br>d. New red sandstone, conglomerate and magnesian lime-stone.</td><td>Supermedial order.</td><td>Flœtz class.</td><td>Secondary class.</td></tr>
<tr><td>3. Carboniferous rocks, comprising,<br>a. Coal-measures.<br>b. Carboniferous lime-stone.<br>c. Old red sandstone.</td><td>Medial order.</td><td colspan="2">Sometimes referred to the preceding, sometimes to the succeeding class, by writers of these schools; very often the coal-measures are referred to the former—the subjacent lime-stone and sand-stone to the latter.</td></tr>
<tr><td>4. Roofing-slate, &c. &c.</td><td>Submedial order.</td><td>Transition class.</td><td>Intermediate class.</td></tr>
<tr><td>5. Mica-slate.<br>Gneiss.<br>Granite, &c.</td><td>Inferior order.</td><td>Primitive class.</td><td>Primitive class.</td></tr>
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**Art. XXX.—*On the Identity of the Organs of Animals of different Classes, as noticed in a late work, by* M. le Chevelier Geoffroy Saint Hilaire, Prof. du Mus. d'Hist. Nat. &c. &c. *entitled—Philosophie Anatomique. Des Organs respiratoires sous le rapport de la détermination et de l'identité de leurs pieces osseuses.*—Communicated by N. M. Hentz.**

Comparative anatomy has for some years past been cultivated with enthusiastic ardor, by many individuals distinguished by the elevated rank they have attained in the scientific world, and the discoveries in this most interesting pursuit have not been less valuable than numerous. From comparative anatomy, natural history as a science, has drawn firm principles, and characters established on a sure and lasting basis. It will henceforth lead the way to the zoologist, and unfold to him the natural connexions which exist between animals. It will guide the naturalist in his researches, and shed light upon several points of human anatomy, and the physician must look to this as one of the most inviting among the collateral branches of his professional studies. Among those who had chiefly contributed to elevate the science to its present rank, the most distinguished were Duverney, Vic D'Azyr, Blumenbach, Hunter, Monroe, and above all, Cuvier. In addition to the efforts of these, and other distinguished writers, M. Geoffroy Saint Hilaire, in the highly philosophical work, the title of which is prefixed to this article, has done much towards giving comparative anatomy a place among the exact sciences, and from the little attention which it has attracted in this country, notwithstanding its importance, some notice of it may not be uninteresting. Endowed with a strong mind, aided by strict analysis and deep learning, M. Geoffroy has given to the student a work of the greatest value, of which but an imperfect idea can be formed from this brief notice, but which, should it induce others to study it with the attention it deserves, may not be wholly useless.

M. Geoffroy proposes, as the end of his researches, a solution of this question, whether the vertebral animals are organized after some uniform pattern or type.

Animals possessed of a spine have so much analogy with each other, that no observers can help noticing the common principle upon which they all appear to be constructed. Thus the vertebræ of the lizard as well as those of the elephant, have received the same name from persons unac-

quainted with the science of comparative anatomy, and the skull of the most simple animal is, from the first sight, associated with that of our own species. But though this general resemblance might have led us at once to the correct conclusion, yet confusion arose from the circumstance that superficial observers often gave different names to the same object, when presenting itself under different points of view, and with some modifications of external aspect. Thus the superior extremities, which in man and the monkey are called arms, became wings in the bat, and fore-legs in animals that do not walk erect. In this way new terms being introduced, and increased as new modifications are observed, give rise to the belief that some animals may have organs which others do not possess. The simplicity of organization in animals, therefore, is not so evident to those who have made some progress in the science, as it seemed to be at the commencement of their labours. It becomes important then to retrace our steps, and begin anew our examination of animals, without losing sight of our own organization, which we have reason to regard as containing the type of all modifications. This Lamarck had already laid down as undeniable; "it may be stated," he remarks, "as a positive fact, as a truth susceptible of demonstration, that of all organized beings, man has the most complicated and perfect organization as a whole, as well as in the faculties which it procures to him." But we may remark, with M. Geoffroy and Lamarck, vol. 1. p. 136, that though several animals present in some of their organs a higher degree of development than is the fact in regard to man, yet his organization as a whole, must be considered as having reached the highest point of perfection.

To those who have looked upon this subject, as it were at a distance, it might appear that no discussion was required, and that the unity of composition is evident. Those, on the other hand, who have been accustomed to regard some parts of the skeleton, particularly in fishes, as peculiar to that class, may oppose at first a system which leads them back to the point from which they might have taken their departure.

When we consider that in fishes we find united in the same place, the bones which serve as a case, or support to the organs of circulation, respiration, deglutition, of the senses and motion, we may find it difficult to refer all these parts to other parts which we have already observed in quadrupeds and in birds; but let us not forget that some organs in con-

sequence of being somewhat changed in situation, do not cease to be the same organs, and that we cannot expect to find in fishes the same independent although complicated structures which we have before observed. Notwithstanding this, however, we shall discover that these parts have constantly the same functions, and remain invariably the same.

In pursuing this subject we must bear in mind this conclusion, that the trunk exists in quadrupeds under the middle of the spine, in birds under the extremity of the column, and the coccyx, and in fishes under the first vertebræ and the head.

The volume before us contains five distinct memoirs. In the first M. Geoffroy examines the *opercular* bones which in fishes would seem to be new parts added to their organization; he compares them to the corresponding bones of the human ear, viz. the *stapes*, *incus*, *os orbiculare* and *malleus*. M. De Blainville differs from him on this point, supposing that the opercular bones are formed from divisions of parts of the lower jaw; but Cuvier admits the existence of six or seven distinct bones which form the lower jaw in fishes, and we must therefore look to other organs for the determination of the nature of the bones in question. M. Geoffroy then concludes, that the four bones of the internal ear, supposed to be destined to communicate sounds to the brain, are in quadrupeds, birds, and reptiles, nothing more than the four *opercular* bones in fishes; that they are four materials (*materiaux*) given to the organization, susceptible of a maximum and a minimum in their development; that they are highly developed in fishes only; that in other vertebral animals they descend from that elevated rank to the state of mere rudiments of what they may become; that, as they are susceptible of becoming more and more minute, they may disappear entirely; lastly, that, in animals having lungs being incapable of attaining the high functions for which they are destined, they are, as it were, subservient to the organs which surround them.

The second memoir is devoted to the examination of the sternum. M. Geoffroy proceeds to prove, that however varied this bone may be in its different modifications, it may be traced to the same type. His conclusions are as follows.

1st. The word sternum is a collective name; it ought to be applied, and is applied, to an assemblage of pieces which form the inferior part of the thorax, and which necessarily enter into the composition of the chest; either to govern its me-

chanism, or to defend the important organs contained in this cavity, from external injury.

2d. The pieces which compose the sternum have a determined character, and peculiar functions; they are divided into two distinct orders, or series; first, the bones of the sternum properly so called, which are nine in number, if all employed; and second, the sternal ribs, the number of which is not limited.

3d. In some cases of aberration in particular individuals, these pieces are raised to the rank of *principles of organization*, or organs indispensable to their existence, and ought to receive distinct names.

4th. Viewing them in a series, these parts are almost homogeneous, and it is sufficient to designate them as first, second, third, &c. But all these pieces, except a single one, are susceptible of uniting two by two, and in that case they perform different functions. Under this new combination, M. Geoffroy calls them Episternal, Entosternal, Hyosternal, Hyposternal, and Xiphisternal. The entosternal alone is constantly an odd bone, excepting in the ornithorynchus.

5th. The anterior piece (the double episternal) constantly supports the *furcular clavicle*, (*clavicule furculaire*) when this exists; the second, (the *entosternal*) supports the coracoidal clavicle, (*clavicule coracoide*) when this becomes one of the principal supports of the shoulder. The third piece (the *hyosternal*) and the fourth (the *hyposternal*) are two *sisters* running the same chance, appearing or disappearing together, both subservient to circumstances excepting in the tetraodon, and ostracion, where each has peculiar and important functions. Most commonly double, they leave the median line, to be transferred to the wings and serve as assistants to the entosternal. The fifth piece (the *xiphisternal*,) or the bone called in man the xiphoid cartilage, on account of its connexions and relations with the parietes and muscles of the abdomen, is less subject to variation; it always terminates the sternum below.

6th. The bones of the sternum all together are nine in number, both when the breast is narrow and is developed to a great extent in length; and when, entirely different in its dimensions, it becomes as large and broad as possible. In the first case the pieces of the sternum are arranged one after another; and in the second they are united two by two, and in the following order: the two hyosternals, the two hyposternals, and the two xiphisternals.

7th. We are thus led to an *ideal type* for the sternum in all

animals having a spine, which type, when examined more closely, becomes modified in several secondary forms according as the materials of which they are composed are employed in the whole or in part, or even as their dimensions or respective proportions happen to change. These conditions in their variety when this is confined to certain limits are therefore the elements of the sternum of classes of animals, (*sternum classique*) and are sometimes so in regard to some subdivisions pretty well determined for orders and families.

The sternum in each class gives rise to the following remarks.

8th. The character by which the sternum is known in mammalia, is a single series of pieces placed one after another. This secondary type is susceptible of two modifications which thus become the particular characters of two divisions of mammalia. Those possessing nails have their sternum more really formed by a single series of eight or nine pieces, while animals with hoofs which possess a smaller number of these, have the two last pieces placed side by side.

9th. The sternum in birds is at first essentially formed of five pieces; the entosternal, the two hyosternals, and the two hyposternals. Still it sometimes receives as an accessory rudiment anteriorly an episternal with two heads, and posteriorly one or two xiphisternals. Thus it is less the number of these materials than their respective size which becomes the great character of the sternum in birds. The entosternal is highly developed in them. The small size of the episternal and of the xiphisternals might be attributed to this enormous piece, as attracting all the nourishment, since it is larger in proportion as these are smaller. Extended from the episternal to the xiphisternal, it deprives the hyosternals and the hyposternals of their position on the median line, and confines them to the sides. Lastly, its extraordinary size produces this result, that in birds the pieces of the sternum are placed three in a line.

10th. As to the reptiles, we must be satisfied with the following data. The turtles have a sternum which differs from that of the frogs; that of the crocodiles is likewise different from it as well as that of the tupinambis, lizards, salamanders, &c. Consequently there is no uniform sternum for the class of reptiles; the only general remark that may be made in regard to them is that the complication of the

sternum varies in them as the quantity of respiration which is proper to them varies or increases.

11th. The sternum of fishes with a bony skeleton is, on the contrary, very limited; it is composed like that of birds, with the exception of the entosternal and the xiphisternals; consequently composed of one episternal with two heads, and auxiliaries (the hyosternals and hyposternals.) There is no longer an entosternal which surmounts the rest, therefore there is no obstacle to the development of these five pieces; consequently they increase indefinitely in size, till they reach and rest themselves on the os hyoides. One of the clavicles in birds prevents the hyosternal and the episternal from coming in contact. These pieces are likewise separated in fishes. Their motions and use vary so much that we might suppose them to have no analogy with each other.

12th. But whatever these sternums may be, and however surprising their changes may be, it is not difficult to trace their diversity, to perceive that they are converted from one to another, to embrace all that they have in common, and to refer them to one and the same standard (*mesure*,) to the same functions, and in a word to one single type.

The author next examines the os hyoides, which he more easily proves to be the same in all animals having vertebræ, though the number of pieces forming this bone varies in the three classes of animals, viz. nine in fishes, eight in birds, and seven in the mammalia; yet it may be clearly perceived that this difference does not bear upon the branches of the bone, but upon its body, which according to the class is composed of one or more pieces; thus there are no new parts, but modifications of parts previously existing.

M. Geoffroy continues the application of his system to the internal bones of the thorax, which contribute to direct the surrounding fluid to the pulmonary vessels; this leads him to examine the larynx, trachea, and bronchia in animals which breathe the air, and the respiratory organs in fishes. It is not my intention at this time to follow him in all these researches; suffice it to say that the same spirit of true philosophy pervades this part of his work. Some of his views in regard to the theory of the voice may be briefly noticed. He thinks that the larynx in birds is not an organ separate and peculiar to this class, and that the larynx itself is no more than the first crown of the tube which conveys air to the lungs, and not an organ consecrated only to the voice, since it is one of the principal parts employed in deglutition. The

following passage is worthy of remark. "The intervention of the vocal strings (*rubans vocaux*,) in the centre of the larynx and on the passage of the air, is the most favourable circumstance to the production of voice. In fact what the muscles of expiration have already prepared is completed by these obstacles; the condensed air of the lungs as it presses against these strings, and endeavours to escape through their intervals is there directed or *polarized*. These obstacles by producing the *polarization* of the air, with the additional aid of the two aponeurotic layers, give to the trachea and cartilages, which line the upper part, the character of an instrument of music. Thus the air-tube becomes a vocal instrument, from the moment that it has acquired, and because it has acquired, the means of modifying the air transmitted by the lungs; of governing this new product, and of directing it on the surrounding atmosphere without. It is as it were the tube of a flute yet imperfect, which receives its stopple and is then converted into an instrument of an enchanting effect. The vocal strings, which we may in the same manner consider as the perfecting of the larynx, in regard to its application to the voice, procure then in this respect a new function for all the appendages of the pulmonary organ, by causing them to concur in producing the phenomenon of voice."

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Art. XXXI.—*Some account of the discovery of the Fossil bones of the Mastodonte or great American Mammoth, and of the Anatomical character of that Animal.*—By John Ware, M. D.

In the first number of this Journal was published a pretty full account of the very interesting discoveries and observations made by Professor Buckland, of Oxford University, in the lately discovered cave at Kirkdale in Yorkshire. The singular nature of the facts brought to light by the investigations of Professor Buckland, and the very curious and important inferences that may be drawn from them, show the great value, in a scientific point of view, which all researches of this kind possess. The bearing which they have as materials for a history of the animal creation, and at the same time of the revolutions which have from time to

time taken place upon the surface of the earth, whether gradual or violent, is too obvious to need illustration.

Animals are for the most part composed of substances, which become so speedily decomposed as to leave but feeble traces behind them. Those of the lower classes which have neither an internal bony skeleton nor an external calcareous covering, and consist merely of a soft and perishable mass, can in no way leave any mark by which their existence may be indicated, except, 1st, by making an impression during life or soon after death upon some soft substance which on hardening retains it permanently; or 2d, by undergoing what is usually called the process of petrifaction. Of those animals, however, that have some parts of their bodies composed of more solid materials, such as shells or bones, we are possessed of more satisfactory memorials. They are frequently found in a most perfect and wonderful state of preservation, even after the lapse probably of many thousand years, and after being subjected to several successive revolutions of the earth's surface. And from the study of these animal remains with reference at once to their anatomical and geological character, the most important results have been obtained, with regard to the changes which have in past ages taken place in the structure of the globe.

The occurrence of marine shells and the remains of marine animals in situations to which they never could have attained in the ordinary course of events, are facts which have been long and commonly known, and the general inference has of course been drawn from them, that either the ocean has at some past time covered the places where these remains are now found, or that they have been by some violent commotion thrown up from the bottom of the ocean to that which they now occupy. But the researches of modern geologists have carried them much farther. They have investigated the subject so attentively as to ascertain that these remains belonged to animals of species entirely different from any now inhabiting the globe; and that they differ in a greater or less degree according to the age of the strata in which they are found.

It is assumed that those rocks on which all others rest are the most ancient; and that the age of all other strata is to be determined by their degree of proximity, in point of superposition, to these. Following this principle, it has been found, that in the oldest formations only the remains of the most imperfect of the animal creation are to be detected, and that, as the strata become more modern, those

of the higher classes are discovered; but that the organic remains, even of the same class, of the older strata differ from those found in the more recent, and that they all differ from those of the animals which now inhabit the earth, though those of the recent, bear a closer resemblance to existing races, than those of the ancient strata. The remains of animals now existing are only to be found in the most recent alluvial deposits; that is, in deposits not the consequence of any grand convulsion of nature, but of the gradual changes constantly taking place upon the face of the earth. Two general results then of considerable importance seem to be established by these investigations; first, that only the more recent strata contain the remains of the higher classes of animals, whilst the ancient present only those of the more imperfect, and 2d, that where remains of animals of the same grade are found in strata of different ages, those animals are never of the same species with each other, and never of the same species with those now existing.

It is obvious, if confidence is to be placed in these results, that the investigation of the anatomical character of the organic remains of animals, must have been carried on with great delicacy and success, and that this branch of the science can be considered in point of interest and importance, as inferior to scarce any which has engaged the attention of modern geologists. It is, however, with regard to the remains of animals of the higher classes, particularly, mammalia and birds, that the principal interest must be excited; partly from the nature of the animals themselves, which from the character of their remains, present more striking distinctive marks and appear capable of being more accurately distinguished; and partly, because they probably are indications of some revolutions, in the catastrophe of which the human race were also sufferers, or which at least approached very nearly to the time at which our species made its appearance upon the globe.

It is only within a short time that the study of fossil bones has been pursued with sufficient accuracy to be capable of affording such satisfactory conclusions. Even the most distinguished anatomists of the last century were able only to form some tolerable conjecture with respect to the nature of these unknown remains when they were presented to their examination. Their inquiries had not been directed to this subject. They did not possess that thorough and extended knowledge of comparative anatomy, upon which alone it is safe to proceed. It is to Cuvier that we indeed owe the

very existence of this part of science. Having devoted a great part of his life to the investigation of this subject, he has arrived at such a degree of certainty, that from a few of even the smaller bones of any animal, he is able to determine whether it belonged to any existing species or whether it has become extinct, and if extinct, in what order and with what genus it is to be arranged. Proceeding in this way, he has discovered among organic remains, the bones of many extinct species of existing genera, and also those of several genera, which have become extinct. The whole number of species whose fossil remains have been thus examined amount probably to nearly one hundred: of these, a great part are certainly unknown to naturalists of the present day, and of the remainder it is yet somewhat doubtful whether they belong to any existing species or not.

It is natural that discoveries so extraordinary as these should excite something like incredulity in those who are unacquainted with the principle upon which this celebrated philosopher has proceeded in his researches. The following extracts from the writings of Cuvier himself, will sufficiently illustrate his mode of research, to remove any prejudices that might be produced by the surprising nature of the discoveries themselves. "Being engaged," says he, "in antiquarian researches of a novel character, I have been obliged to learn the art of decyphering and restoring these monuments, (the fossil bones,) of recognising the scattered and mutilated fragments of which they consist, and replacing them in their primitive arrangement; of reconstructing those ancient beings, to which they belonged; of exhibiting their proportions and characters; and lastly, of comparing them with those, which are found at this moment on the surface of the globe; an art almost unknown, and which presupposes the existence of a science hitherto almost untouched, I mean that relating to the laws of coexistence, which regulate the forms of the various parts of organized beings. I could only prepare myself for these researches by much longer researches on existing animals. It was necessary to review almost the whole of the present creation that I might give the force of demonstration to my conclusions respecting the extinct creation. This review produced numerous rules and relations of a character not less demonstrative; and thus by means of this inquiry into a small part of the theory of the earth, I was drawn into the discovery of new laws, applicable to the whole animal kingdom."*

* Researches on the fossil bones of quadrupeds. Preliminary Discourse.

What is meant by the laws of coexistence which regulate the forms of the various parts of animals, is well illustrated in the following passage taken from the same work. "Every organized being consists of parts which correspond mutually, which concur by means of reciprocal influences in the production of a common end, and thus form together, a whole, a perfect system. No one part can change, without the others being modified; and consequently each, taken separately, modifies all others.

"Thus, if the intestines of an animal are adapted by their organization to digest flesh, and that in a recent state, the jaws must be constructed for devouring prey; the claws for seizing and tearing it; the teeth for lacerating and dividing its flesh; the whole apparatus of moving powers for pursuing and overtaking it; the organs of sense for perceiving it at a distance; nature must moreover implant in the brain, an impulse or instinct, leading such a creature to conceal itself and lay in wait for its victims. Such are the general conditions of the carnivorous regimen. Every animal that feeds upon flesh necessarily unites them; for its species could not otherwise subsist. But, besides these general conditions, there are subordinate ones, relating to the size, the species, and the abode of the prey; and each of these secondary conditions gives rise to differences of detail in the forms which result from the general laws. Hence not only the class, but the order, the genus, and even the species, are expressed in the form of each part.

"To give the jaw the power of seizing, a particular form of condyle is necessary. There must be a certain relation between the position of the resistance, the moving power and the fulcrum; a certain volume in the temporal muscle, requiring a proportional volume in the fossa which lodges it; and a proportionate convexity in the zygomatic arch, under which it passes; this bony arch must also possess a certain strength, to support the action of the masseter. In bearing away the prey, a certain force is required in the muscles that raise the head; hence the necessity of a determinate form in the vertebræ, whence these muscles arise, and in the occiput where they are inserted. For dividing flesh, cutting teeth are required; and they must be more or less cutting, in proportion as they are more or less exclusively occupied in that way. Their basis must be solid, if they are employed in breaking and comminuting bones, particularly if the bones are strong. These circumstances will influence the development of all the parts employed in moving the jaw.

"Mobility of the toes, and strength of the nails, are necescessary for seizing the prey; hence arise determinate forms of the phalanges, and particular distributions of muscles and tendons. There must be a power of rotating the fore-arm, and consequently a particular form of the bones composing it; and as the latter are articulated to the humerus, any alterations in them must modify its figure. Animals which employ their fore-limbs in seizing must have strong shoulders; the scapulæ and clavicles will therefore exhibit certain modifications. The muscles must have forms, size and strength suitable to the actions of which the bones and joints just enumerated are capable; while their attachments and contractions impress particular figures on those solid organs.

"Similar conclusions may be drawn respecting the posterior extremities, which contribute to the rapidity of the general motions; respecting the composition of the trunk, and the form of the vertebræ, which influence the facility of those motions; respecting the bones of the nose, of the orbit, and the ear, which have obvious relations to the degree of perfection in the senses of smelling, seeing, and hearing. In a word, the form of a tooth determines that of the condyle; the form of the scapula that of the nails; just as the equation of a curve indicates all its properties. As in taking each property separately for the basis of a particular equation, we might arrive, not only at the ordinary equation, but at all other properties whatever; so the nail, the scapula, the maxillary condyle, the femur, and all the other bones taken separately, would each indicate the kind of teeth, or would indicate each other reciprocally; and beginning with either separately, we might, according to the rational laws of the organic economy, construct the whole animal*."

Upon the principles deduced from these views of the mutual relations of the organs and the laws of coexistence which are to be recognised under all their variations and combinations, Cuvier, and other modern anatomists have proceeded in the examination of fossil bones. They have been enabled to prove beyond a doubt that the greater part differ from those of any animals now existing, and that they consequently belonged to races of beings which have long since

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* Researches on the fossil bones of quadrupeds.—Preliminary Discourse. In the Anat. Comp. of the same author, vol. 1. p. 46, may be found a discussion of the same principle in a more general point of view, but equally clear and instructive with that quoted above.

disappeared from the globe, or at least have not inhabited it within the memory of the human race. Among the organic remains of quadrupeds which have thus been investigated, those of the great Mastodonte or Mammoth of America, are possessed to us of peculiar interest, as having been discovered in our own country, and are also subjects of the greater scientific curiosity, from the fine state of preservation in which they have been found, and from being at once the largest of all fossil animals, and the first which convinced naturalists, beyond a doubt, that there had formerly existed species of animals which have now become extinct.

The term mammoth which has been applied to this animal does not, strictly speaking, belong to it. Its application arose in the first instance from a mistake of Dr William Hunter*, who, upon an examination of some bones brought to London in the year 1767, concluded that they were probably of the same kind with some large fossil bones found in Siberia, which however he had never seen, and which were believed by the natives of that country to belong to some large unknown animal called mammoth, since proved to be a species of elephant. Cuvier, after an examination of the anatomy of both animals, pronounces them to be not only distinct in species but also in genus, and has given to the American animal the name Mastodonte, from the peculiar form of its teeth. This is doubtless the strict scientific name, but custom, particularly in America, has so long authorized the application of the term mammoth also to the American animal, that I deem it not improper to make use of it, particularly as the true mammoth being shown to be a species of elephant, the term Siberian elephant seems a more correct, and is now in fact, a name more commonly employed to designate it.

The bones of the mammoth were first discovered more than a century ago, but they did not at first excite much attention, and the ideas which were entertained with regard to them, were very vague and loose. It was not till the accounts published of them by Collinson and Hunter near the middle of the last century, that they fairly became subjects of scientific curiosity.

The first mention of the American bones, upon record, appears to be that made by Dr Cotton Mather, of Boston, in a paper communicated to the Royal Society in 1714†. The

* Philosophical Transactions, vol. 58, 1767.

† An account of some observations made in New-England.—Phil. Trans. 1714.

object of this worthy divine seems to have been to corroborate by the discovery of these bones, the account given in Scripture of a race of antediluvian giants. He inclines to this opinion from the circumstance that bones have been dug up in America of an immense size, and yet resembling in their formation those of the human body. These bones, he states, were found in 1705, near Albany, on the Hudson. Among them was a grinder weighing four pounds and three quarters, another tooth broad and flat like an incisor, a third like the eye-tooth of man when worn away by mastication, and a bone, supposed to be that of the thigh, which was seventeen feet in length. The ground for seventy-five feet around the spot where these bones were discovered, he asserts to have been of a different colour and substance from the surrounding; a difference which he attributes to the effects produced by the rotting of the flesh of the animal. Some of these bones were found at a distance of fifty leagues from the sea, and at a great depth in the earth. An account so manifestly tinctured by credulity, and evincing such entire ignorance of anatomy, excited but little attention in the scientific world, and scarce any further notice of these bones can be found for nearly thirty years.

In the mean time, however, in the year 1737, we find some account of the Siberian elephant, published by Dr John Phillip Breyne*. He calls it the mammoth or mammut, and states that its bones are found imbedded in the mountains of that part of Siberia which approaches the Icy sea. It appears that when the rivers, swelled by the melting of snow, or loaded with large quantities of ice, tear away the sides of the mountains that stand on their banks, these bones are disembedded in immense quantities; in such abundance indeed as to be a valuable object of commerce, and monopolized by the Czar. Skeletons had been found nearly complete and appeared to be those of an elephant. The ivory had been used as an article for manufacture, and was not different from that in common use except in being more brittle. Dr Breyne refers the destruction and imbedding of these animals to the deluge, and states the fact, that some bones, apparently of the same animal, had been found in Poland, Germany, Italy, England, Ireland, &c.

In 1739, M. Longueil, a French officer, travelling with a party on the Ohio, a number of savages who accompanied

* Phil. Trans. vol. 40, 1737.

him, discovered at a small distance from the river, in a morass, a number of bones, grinders, and tusks of the mammoth. One femur, the end of a tusk and three of the teeth were carried by him to Paris, where they still remain. They were examined afterwards by Buffon and his celebrated coadjutor Daubenton. The tusk and femur were believed by the latter to belong to the elephant, but the teeth to the hippopotamus, and hence he drew the conclusion, that the morass or salt lick where these bones were found was the depository of the remains of at least two species of animals.

After the peace of 1763, an Englishman, Mr George Croghan, discovered in a bank near the great salt lick, or the *big bone lick*, an immense number of bones and teeth, which he computed must have belonged to as many as thirty different individuals. They were found at about five or six feet from the surface of the earth. Among them were a number of tusks of pure ivory, some of which were seven feet long. From the presence of the tusks he believed that these were of course the remains of the elephant, but could not account for the fact that there were no molares of that animal among them, whilst there were great numbers of large pronged teeth, which as he supposed bore no resemblance either to those of the elephant or any other known animal.

In 1767, Mr Collinson* published the results of his examination of these bones. Upon a comparison of the tusks, he found that they corresponded very nearly with those of the Indian or Asiatic elephant. But from the dissimilarity of the molares, he was led to conclude that both tusks and molares belonged to an unknown species of elephant; or else that they were the remains of some vast animal, never seen in a living state, which was possessed of tusks like those of the elephant, but of grinders of a peculiar construction, and differing from those of any other animal. He conjectured farther, that it was not carnivorous, but browsed on shrubs and the smaller branches of trees. It is to be remarked that Collinson is the first to whom it seems to have occurred as probable, that the bones, teeth and tusks, thus found together, belonged all to the same species of animal, and that his conjectures respecting its nature approach very nearly to the truth, as subsequent investigation has proved.

* Phil. Trans. vol. 57, 1767.

In the next year*, Dr William Hunter entered into an examination of the same subject. His mistake in confounding these bones with those of the Siberian elephant has already been mentioned. The tusk appeared to him to be that of an elephant, but the molares which he considered as belonging to the same animal with the tusk, threw some difficulty in the way of that supposition. These, both he and his brother the celebrated John Hunter, concluded were not those of the elephant. It was the opinion of John Hunter, as expressed to his brother, that from the knobs or conical processes upon the grinding surface of the teeth, and the existence of a coat of enamel upon their outside only, they belonged to some animal which was either wholly carnivorous, or at least partially so. Their conclusion, therefore, was, that both tusks and teeth belonged to the same animal, that this animal was partly at least carnivorous, was the same as the Siberian elephant, or true mammoth, and differed specifically from the African and Asiatic species.

On the continent about ten years after these observations had been made in Great Britain, the attention of naturalists was called to this subject. In 1777 Pallas published an account of six molares resembling those from America, which had been discovered among the Oural mountains; Buffon also asserted that they had been found in many places in the ancient continent, and gave an engraving from one which had eight or ten conical processes and weighed above eleven pounds. About the same time Camper proved satisfactorily that so far as the anatomy of this animal was known, it bore a greater resemblance to the elephant than to any other, notwithstanding the great similarity of the tusks to those of the hippopotamus. He also suggested, for the first time, that it was probably possessed of a trunk resembling that of the elephant, and at any rate was not carnivorous. This, as it will appear, was a gradual approximation to the truth; but unfortunately, a few years afterwards, the same celebrated anatomist came into the possession of some imperfect drawings of a part of the head and upper jaw, in which he considered that part of the bones as belonging to the anterior part of the jaw, which in reality belonged to the posterior; in short he viewed them in a reversed position. He was, in consequence of this error, induced to change entirely his opinion and to declare that the great animal of the Ohio

* Phil. Trans. vol. 58, 1768.

must have had a pointed snout and no tusks, and that he was at a loss how to reconcile all the circumstances*.

In the year 1780, a very interesting discovery of mammoth bones was made by the Rev. Robert Annan†, on the banks of a small river named the Walkill, about seventy miles from the city of New York, and fifteen miles from the Hudson. The bones were first observed by a young man digging a ditch, who remarked that he had found some strange stones in the ditch, meaning the grinders, for the other bones were so soft that he cut them easily with his spade, and they had therefore escaped his notice. Upon examining the spot, many of the parts of the skeleton were found in their natural relative position. The vertebræ were traced out in a line in their proper connexion, and with them the bones of the pelvis and of the lower extremities. It is probable also that the head might have been found had it not occupied the spot intended for the ditch where it had been destroyed in the first instance by the workman. The bones were discovered within a few feet of the surface, but were in an exceedingly decayed state, and would hardly bear a thorough examination. But from their size, and the form and structure of the grinders, as described by Annan, there can be no doubt that the animal was the mammoth, and that, had an opportunity been had for a careful examination in the first instance, a complete skeleton might have been here found in its natural connexion.

During this period many different bones of the same great animal had occasionally been discovered, but nothing like a complete skeleton was obtained until the commencement of the present century.

In the year 1801, Mr Peale, of Philadelphia, by great industry and perseverance, succeeded in collecting from various parts of the state of New York one or more specimens of every bone in the skeleton of the mammoth, with the exception of part of the cranium; and having duplicates of most of the principal bones, proceeded to form two skeletons, substituting in one, artificial copies of those bones of which

* The papers of Pallas and Camper are contained in the Nova Acta Petropol. Tom. 1. P. II., but an account of them is given in Annales de Museum, Tom. 8. Camper died without perceiving the error into which he had fallen, but his son has acknowledged, after a correspondence with Cuvier that the father had been mistaken in the last views he had taken of the subject.

† Trans. Amer. Acad. vol. 2. p. 160.

he had not a double set. One of these was transmitted to London, the other remains in the museum at Philadelphia. With the exception then of the upper part of the cranium, the osteology of the mammoth was complete.

In 1805, Bishop Madison of Virginia communicated to Dr Barton, of Philadelphia, an account of a discovery of mammoth bones in a spot to the west of the three grand chains of mountains in that state. They were found at a depth of five and a half feet under ground; the country around the spot where this discovery was made is full of calcareous stone, in which there are numerous impressions of shells, and the caverns afford a good deal of nitre and of the sulphates of soda, magnesia, and barytes. The bones formed nearly a complete skeleton; but the most remarkable and curious circumstance connected with them, was, that in the midst of them appeared a mass composed of the half bruised branches of trees, shrubs, grass and leaves, among which was recognised a species of rose still growing in Virginia. All these substances were disposed just as if they had been enveloped in a kind of bag, which may be supposed to have been the stomach of the animal, and these the aliment on which he had been feeding.

In connexion with this account it may be mentioned, that some of the savages who have been acquainted with the bones of the mammoth, have asserted that among them has been found a skeleton with the remains of the soft parts connected with it, and that it had a long projecting nose and a mouth beneath it, a description which corresponds very well with that of the trunk and mouth of the elephant. It is also stated by Kalm, that in a skeleton found upon the river Illinois, which he took to be that of the elephant, the traces of a proboscis were still distinguishable, although in a state of decomposition. These facts render it more probable that the mass of triturated vegetable substances above mentioned really had been the contents of the stomach of the mammoth. But even farther than this, the foot of an animal, in a dried state, has been exhibited in Paris, which was said to have been found by a Missouri Indian in a cave along with a tooth of the mammoth. The possessor bought it of a Mexican who had it of the original discoverer. If this account were authentic it would go far to raise a doubt, whether the species were extinct. But according to Cuvier*

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* Annales de Mus. tom. 8.

there are many circumstances which render the truth of this statement doubtful. The foot appears too fresh; it appears as if it had been cut off from the leg of the animal, and looks too much like that of the elephant.

Within the last ten years, the Big Bone Lick, the most celebrated depository of the bones of the mammoth, has been explored anew by General W. Clark, so well known by his journey to the Pacific Ocean as the companion of Lewis, at the request and under the direction of Mr Jefferson, at that time president of the American Philosophical Society, who also furnished all the means necessary for so expensive an undertaking. A large number of bones was collected and submitted to the examination of the late Dr Wistar. "I found," says Dr Wistar, "that the great mass consisted of the bones of the large animal formerly of this country, to which the name of Mastodonte has lately been given by M. Cuvier. Among these were also some large teeth which I supposed belonged to the elephant of Siberia, and several specimens of large teeth of the same kind, with the lower jaw-bones to which they belonged, evidently of young animals. There were also several tusks; one similar to that which Mr Peale procured with his skeleton of the Mastodonte, and some others of the elephant of Asia or Africa*." It was the intention of Mr Jefferson that all new bones which might be discovered should be retained by the American Philosophical Society, but all duplicates presented to the Institute of France. Under the direction of Dr Wistar the selection was made, and the intention of the venerable philosopher carried into effect.

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Art. XXXII.—*Description of an Egyptian Mummy, presented to the Massachusetts General Hospital; with an account of the Operation of Embalming, in ancient and modern times.* By John C. Warren, M. D., Professor of Anatomy and Surgery, in Harvard University.

(Continued from p. 179.)

The science of the moderns has never been directed to the preservation of the dead, except for anatomical pur-

* Trans. American Philosoph. Soc. Vol. I. New Series, 1818.

poses; of course the practical perfection of the art of embalming does not exist in so high a degree, as among the ancient Egyptians. It is, however, probable that a due application of the discoveries in anatomy and chemistry, would admit of our accomplishing the process in a more perfect and elegant manner, than they have been able to do.—Some attempts of the kind have been made from time to time with sufficient success. The bodies of kings are generally embalmed in Europe, and we have examples of their having been well preserved for two or three centuries. When the remains of the French monarchs, in the Abbey St Denis, were disinterred, under the inspection of the brutal Robespierre, the body of Henry IVth, who was assassinated in 1602, was found so perfectly preserved that the features of the face remained, and were seen to possess a decided likeness to his statue on the Pont Neuf in Paris. At the same period the body of Marshall Turenne presented itself in fine preservation, and it was thought worth while to exhibit it, in a glass case, for the space of a year, after which, some persons contrived to have it removed from the public gaze and deposited in a tomb in the splendid chapel of the Invalids. No account has been transmitted of the manner in which these bodies had been treated; and it was not even known until the period when it was disinterred that the body of Turenne had been subjected to the embalming process. The French surgeon Dionis, who lived at the time Turenne was killed, in 1675, gives a very particular account of the operation he performed for embalming the body of the Dauphiness of France. But this appears to have been so very inadequate that we can scarcely believe it to have accomplished its object, even for a few years. He opened the cavities and removed the viscera, then, after cleansing and washing the parts with alkohol, he filled them with an aromatic powder made of a multitude of herbs, and with another made of gums: the same was done with the limbs by making incisions in different parts: the surface of the body was anointed with a liniment of spirits of turpentine, styrax, &c., and then the body was swathed in bandages and placed in a leaden coffin. The aromatic plants could have the effect of only retarding the decomposition of the body a few days, by imbibing its moisture: and the anointing with the liniment could scarcely be expected to do as much.

Different operations may be employed for the preservation of the bodies of our departed friends. If it is desired

to preserve the body for a short time only, in order to delay the period of its burial, the following course may be adopted. The viscera should be removed and placed in a separate receptacle. Then the limbs and neck must be compressed to expel the contents of the blood vessels, which are to be carefully absorbed by sponges and removed. After this is done, the body must be made as dry as possible; cloths dipt in a solution of corrosive sublimate, of the strength of two ounces to a pint of alkohol, are to be laid in all the cavities, and the skin is to be carefully sewed. This operation, which may be performed in an hour, will preserve the flesh from putrefaction for many days. The preservation may be rendered more perfect by throwing some of the mercurial solution into the principal blood vessels. If it is to be kept a considerable time, it should be immersed in a solution made of corrosive sublimate in spirit, placed in a wooden trough, the cavities being opened so as to expose the viscera to the action of the liquid, and in this situation it may be preserved from putrefaction, for any length of time, provided fresh portions of sublimate are added from time to time, and the waste of liquid properly repaired.

By a more complicated and expensive process we are able to imitate and surpass the art of the Egyptians; to give not merely durability to the human frame, but even to revive its extinguished colour, and so far to restore the expression of the face, as to give some resemblance to life. This mode of embalming has also the advantage over that of the Egyptians, in allowing us to see and even touch the body, instead of its being swathed in bandages and covered for ever from the sight. It is to be remembered, however, that we do not possess the uniform temperature and the dry atmosphere of Egypt: circumstances that make an incalculable difference in the decomposition of all decomposable substances. In Egypt, it has been said, it never rains; and in fact the rains are very slight and rare. Hence is it that the monuments of that country have retained such wonderful perfection, while others equally solid erected a thousand years after, have long since crumbled into dust. Not only the mummies of Egypt, but their catacombs and even the pyramids, would probably have been torn in pieces long since by the frosts, heats, and rains of our climate. Having thus the inconvenience of climate to contend with, we cannot expect to gratify our ambition of excelling the Egyptians in the actual duration of our mummies; unless indeed we were to deposit them in deep and rocky recesses, rendered inac-

cessible to air and moisture, and to the variations in the temperature of the atmosphere.

The operations should be commenced as soon after death as may be; although they will succeed at any stage short of actual putrefaction. The chest is to be opened by sawing the sternum and introducing the pipe of an anatomical injection syringe into the left ventricle of the heart. A liquid is to be prepared, consisting of alkohol with corrosive sublimate dissolved in it, in the proportion of four ounces to a pint of liquid; and with this the vascular system is to be fully injected. On the following day, the pipe is to be opened, and as much of the liquid, as remains in the large vessels, allowed to escape by turning over the body. Then an injection is to be prepared of white spirit varnish with one-fifth part of turpentine varnish, coloured with vermilion, to be injected in the same manner as the first. In three or four hours after, a coarse injection is to be employed, to fill the large arteries; and this may consist of the common cold injection, or the body may be immersed in warm water; and a hot injection thrown into the blood vessels. When the coarse injection has become hard, the abdomen is to be opened by an incision of the linea alba; all the viscera are to be removed, and after being cleansed they are to be deposited in a separate vessel, containing a solution similar to that in which the body is to be immersed. The brain is to be removed by an incision of the scalp and sawing the skull in the usual mode: then the brain is to be treated in the same manner as the other viscera, with the addition to a pint of the mercurial solution, of four or five ounces of muriatic acid. It might be supposed that the thickness of the brain would prevent the solution from penetrating deep enough to affect it; but I have sufficient evidence to the contrary, in a brain prepared in this manner, dried and varnished fifteen years ago, and which is now as perfect as when prepared. The viscera being disposed of, the body is then to be placed, with the face downward, in a wooden trough, containing a solution of corrosive sublimate in alkohol, in the proportions already named, that is, four ounces of the salt to a pint of the liquid; and some additional pieces of the salt are to be put in from time to time, in order to repair its consumption by the dead body. If the subject be adult, it must remain in the solution at least three months: at the expiration of this time it is to be removed and thoroughly washed. The orbits of the eyes, the organs having been

removed, are to be moderately filled with pieces of linen; the cheeks are to be distended with the same substance; the other features to be arranged in as agreeable a manner as circumstances permit; the lips especially may be a little separated, to display the teeth. The great cavities must be made as dry as possible, and this is effected very easily, from the desiccating property of the oxymuriatic solution: then the organs, previously dried, are to be restored to their proper situations, and the remaining interstices filled with linen, dipt in spirits of turpentine, or some of the cheaper gums. Before the body has dried, the cavities are to be carefully sewed up, so as to present their natural shape, having a dependent orifice to each cavity to drain off the remaining moisture. After this, it is to be suspended on cords, in a current of air to dry it. The desiccative process goes on rapidly, and the parts must be constantly watched, to prevent their being distorted. When the drying is completed, eyes of enamel are to be placed, and if the features are not satisfactorily exhibited, they may be improved by the skilful addition of wax and paints, of proper colours. The hair will be preserved and is to be adjusted; then the body is to receive, at due intervals, three or four coats of turpentine varnish; and being invested in a becoming robe, is to be fixed in a glass case made air tight. No insects will approach a body prepared in this manner; and if it be newly varnished every few years, it will remain the same, for an unknown length of time.

In this way we might, for a moderate expence, preserve the appearance of those forms which have been associated in our minds with agreeable occurrences, and we might gratify the curiosity of a remote futurity, by transmitting to them the bodies and even the features of those who have been distinguished among us by their virtues, their patriotism, or public usefulness.

The mummy presented by Mr Van Lennep to the Massachusetts General Hospital was enclosed in a large deal box. On opening this, the outer coffin or sarcophagus appeared, as represented in the plate. It is a wooden box, seven feet long, and of a breadth proportioned to the length, like the proportion of the human body. The upper part of it is carved, in a very striking and peculiar style, to represent a human head; and, as it appears from the authors who have described the customs of the Egyptians, it was intended to be a likeness of the deceased person. The

head is covered with a striped cloth or turban, on the upper part of which is painted a globe. The face has the character which has generally been considered as belonging to the Egyptians. The skin is of a reddish colour, the eyes black, nose broad, but not badly proportioned, mouth well formed. The face is broad and short; it has a very agreeable expression, approaching to a smile. The shoulders are invested with a highly ornamented mantle, on the fore part of which the turban is seen depending. Below the mantle, in the middle, is seen the winged globe, by some considered as the sign for eternity: by others as the emblem of Agathodæmon or Chnuphis of the Greek authors, the oldest representation of the divine power admitted by the Egyptians; and it may therefore be believed to be significant of the immortality of the soul of the deceased, or else to be the symbol of the divine protection.—On each side of the globe are seen hieroglyphics.—In the second compartment or tablet, below the globe, we have the representation of a most singular group, exhibiting the last judgement of the deceased and his reception by various divinities. According to Diodorus the body of every person, from the king down, underwent this ceremony. Two and forty judges were collected on the banks of a canal, where the relations appeared; and a boat being prepared, before the body was put in it, any one might bring forward accusations against the deceased, which, being examined by the judges, if found to be true, prevented the body from possessing the honours of a public funeral: but if they were thought false, the accusers were severely punished; then the relations finished their mourning, pronounced the praises of the deceased, and declared him about to enjoy a happy eternity with the pious in the regions of Hades. In the rolls found with mummies, on the coffins and in the tombs, this judgment is almost always pictured by the figure of a balance in the form of a cross, near which two personages are standing and apparently weighing the merits of the deceased: seeming to officiate as his good and evil genius, each wishing to draw the scale to his own side. Finally the scale of the good genius preponderates; judgment is given in favour of the dead person, and he is then to be introduced to the company of the gods. As a preliminary to this honour, he is invested with some of the insignia of Osiris if a male, and of Isis if a female.

In this tablet, we notice four personages on the left, who are looking to the right, and two persons on the right,

looking to the left. Behind the last of these, that is, on the extreme right, is seen the balance, in the form of a cross, with a Cerberus as the evil genius sitting on its left and a hieroglyphic representation of the friendly divinity on the right. In the second coffin, to be described afterward, this balance is more distinctly and fully represented; the Cerberus is seen on the left; but on the right of the balance appears the friendly divinity in person, bearing the head of a wolf. The figure next the balance without any other garment than a kirtle, is supposed to be that of the deceased, coming from judgment, under the protection of a divinity who has hold of his hand and seems to have taken him under his protection, in order to present him to the assembly of deities. At the head of these is the serpent, supposed by some to have been regarded as the good angel by the Egyptians. Next follows the great Osiris, the principal deity of the Egyptians, designated by his mitre, and his staff or sceptre, the emblem of power; he has the attitude of receiving the new comer presented to him. After Osiris are seen four, or on the inner case five, other personages, bearing the heads of a dog, a baboon, a hawk, a wolf respectively, supposed to be representations of the important divinities Anubis, Macedo, and others. These paintings therefore confirm and illustrate the account of the judgment after death, transmitted to us by Diodorus Siculus.

The third tablet consists of hieroglyphic writing, arranged in columns, extended from above downward, as was the manner of the Egyptians.

The fourth, represents the hearse bearing the coffin of the deceased. The hearse has the form of a quadruped, perhaps a lion; a style of furniture very much affected by the Egyptians. The coffin is represented as carved at the head. Below the hearse are four vessels, containing resinous and odoriferous substances, employed in embalming. At the head and foot are seen the tutelary hawk, or vulture, with stretched out wings, as if to protect the hearse, and between them is an eye with a tear, the symbol for mourning.

The fifth tablet consists of hieroglyphics.

The sixth, placed on the projecting foot of the coffin, exhibits a series of red and white stripes, twenty in number, which may be supposed to indicate the age of the deceased; on the base, supporting these, stands the tutelary hawk, surrounded by hieroglyphics, and among them is distinguished the eye with a tear.

The second plate gives a view of the inside of this case. On the bottom is represented the figure of the great Osiris. He is here invested with the hawk's head, although sometimes he appears with a human head, but never that of any other animal. He is characterized also by his mitre, and by a staff with a crook at the lower end, the symbol of power. On each side is depicted the figure of a young female, intended probably to represent the deceased person in her new character of Isis; for the symbol of Isis, a throne, is seen on the head, and we cannot suppose the figure intended for Isis herself, as this goddess is seen on the inner coffin with different ornaments. In the manuscripts found with the mummies, and in the coffins, the deceased individual is constantly represented in a new and more elevated character, on entering a new state of existence; and is therefore invested with the ornaments and attributes of Osiris if the subject were a male, and of Isis if a female. In this instance she appears with the throne, a form known to be symbolic of the goddess Isis. At the upper part of the coffin, on the inside, above the female figure, are seen a number of hieroglyphics, larger than the rest, and drawn with peculiar distinctness. At the top is the winged globe; below this, a knife or hook, the instrument by which the os ethmoides was perforated to extract the brain; next follows a hand, that of the operator or embalmer; and then a circular figure containing a cross, said to be the symbol of Egypt. The circular mark surrounding the figure of Osiris is that of a serpent beginning and ending in a globe, intended perhaps as symbolic of eternity.

The outer coffin described above, contains an inner coffin of the same form and of smaller size, bearing the principal figures seen on the outer. Instead of the winged globe and hawk, the top and bottom are ornamented with a figure of Isis with wings widely expanded, as a protecting deity. Some of the hieroglyphics of the outer case are replaced by figures, intended to represent priests, in various attitudes of adoration or supplication. The external surface of the inner coffin is covered on the sides and back with hieroglyphics of a large size executed with less care than those on the anterior surface.

Both of these coffins are composed of sycamore wood, in a state of fine preservation. It is decayed only where the plaster has been broken; and in such places the decay is limited, the decayed part being reduced to powder, while that which surrounds it is not affected. Both coffins are

covered with cloth cemented to them by gum; the outside of this cloth is coated with a fine white plaster, on which all the figures are painted. The colours of the latter are yellow, red, blue and green on a white ground; they are well preserved and bright, especially those of the inner coffin. The bottom of the outer has no coating of cloth, but the wood bears marks of having been set in a bed of plaster, which, of course, sufficiently guarded it. Each of the coffins is dug out of two pieces of solid wood, one for the top, the other for the bottom; secured together by projecting pieces of the one received into corresponding cavities of the other, as is seen pictured on the edge of the coffin in Plate II. Both of these cases had been opened by cutting through the cloth opposite the junctures of the cases. This was probably done by the Arabs who discovered them in the catacombs, in order to ascertain if any gold or other valuable reliques were enclosed with the body.

This mummy is about five feet long, heavy, and solid to the touch. A single cloth of a yellowish colour enveloped the whole body from head to foot, being confined closely and neatly to the body by a number of transverse bands of a white colour, under which lay the reliques of corresponding dark coloured bands, so much decayed as to crumble to atoms on being touched. The dark bands were broader than the white, so as to exhibit their edges and produce an ornamental effect; but the colouring substances had caused them to decay, while the others remained entire. At the feet lay a large heap of beads, composed of green and yellow porcelain, partly connected by threads, whose decay had caused the network to fall in pieces. A green network like this is seen covering the bodies of Osiris, in Plate I., and the winged Isis on the inner case: and there is no doubt it was intended to invest the whole of the body for some religious purpose. As the beads could not be shown in their disconnected state, they have been put together and placed on the mummy, though not in the original form, but as well as circumstances permitted. Some of the beads are still very firm, others crumble on a slight pressure.

In order to examine the state of the body, I cut through the external cloth, where it covered the head, and found a great many turns of bandages about three inches wide, rolled around, to the number of twenty-five thicknesses. The outer cloth and the outer turns of bandage were in fine preservation and of considerable strength. They exhi-

bited marks of having been imbued with some glutinous substances, intended to preserve them; and to which is to be attributed the yellow colour. The inner turns were more decayed as they were nearer to the body; those next it were quite rotten, and so closely cemented to the surface as to be separated only by a laborious process. The cementing substance is asphaltos, the same in which the body is embalmed. This substance was quite dry, hard, and brittle. Imbedded in it, on the nose, was found a beetle, and near this another small insect, whose character could not be determined. The beetle was a sacred animal, in high estimation among the Egyptians, and seems to have occupied a distinguished rank in their theology, from the conspicuous place assigned it in the zodiac of Tentyra and other great monuments. It is generally connected with and appears to be holding a globe between its claws, and has been supposed to be the symbol of fecundity.

The skin of the face being exposed, was dry, hard, of a black colour, and its texture readily distinguishable, although deeply imbued with the embalming bitumen. It was wrinkled as if it had been exposed to the action of great heat, or pressure while in a soft and yielding state; and the latter cause has produced a distortion of the features, from the right to the left side. The sockets of the eyes are filled up, the eyelids preserved; but the eyebrows, together with the other hair, is removed or destroyed near to the head, probably by the action of heat; just enough of it remaining however to show that it was not black nor crisped or woolly, but of a brown or reddish brown colour. The teeth are perfect, so far as they can be seen; quite white, and shaped like those of the European, contrary to the opinion of some learned men that the Egyptians had the incisor teeth pointed like the canine or dog teeth. (V. Blumenbach, &c.*) The ears are small, and well filled with embalming substance. The skin of the scalp has the same appearances as that of the face.—Being unwilling to disturb the coverings of cloth and bandage, I left every thing on the body in the same state as it issued from the sepulchre of Thebes. The bandages about the neck were afterwards cemented together, to prevent the air from entering, and the head of the mummy was invested with a cloth formed into something like those represented on the heads of the cases, in-

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* This subject will be adverted to hereafter.

stead of the turns of bandage which had originally enveloped it.—Every part examined was deeply impregnated with the embalming substance, which proved, on examination, to be asphaltos, the bitumen of Judea*. When the bandages were first opened, no great odour issued from the body; but after it had been exposed a few days, a very strong and peculiar smell was perceived, and continued to exhale, until the body was enclosed in a case made very tight. The exposure to air did not, however, alter the skin otherwise, than to produce a whitish saline efflorescence on its surface, which consisted of sulphate and carbonate of soda, and this, being wiped off, did not re-appear when the body was placed in its case.

The appearances about this mummy accord so perfectly with those which have been generally described by travellers and authors, as to leave no doubt of its being genuine. The figures on the cases, the colours, the subjects, the characters, the plaster, the wood, the cloth investing the body, the arrangement of the bands, the embalming substance, the body itself, all agree with the descriptions which have been formerly published, and carry marks of the labours of ancient Egypt. Among the peculiarities not already noticed is the texture of the cloth; it is wrought in a very even and workmanlike manner, and the threads of which it is composed, are doubled and twisted. The painted colours retain that brightness, so often spoken of by those who have examined the catacombs. The style of the figures is truly Egyptian, and could hardly be imitated by modern art. For more perfect satisfaction, the different parts composing it were submitted to artists and men of science, who perfectly agreed in identifying them with the corresponding parts of other mummies. Professor Everett, whose extensive science and observation particularly qualified him as a judge, and my other colleagues, Doctors Jackson, Gorham, Channing, and Bigelow; also, George Blake, Esq. Dr Webster, and various other gentlemen, examined the different objects before they were enclosed in cases, and though some of them had been previously sceptical, they were perfectly satisfied after making their examination. I mention these circumstances because the accidental coincidence in

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* *Asphaltos* is a black, inflammable, bituminous substance, like pitch; chiefly found floating on the surface of the Dead Sea, or Lacus Asphaltites, in Judea, on the spot where stood anciently the cities of Sodom and Gomorrah.

time of its appearance in Boston, with the intelligence of an imposition in natural history lately practised in Europe, had rendered many persons suspicious of the true character of this mummy.—If, in addition to what is stated above, any farther confirmation of its genuineness were required, it might be obtained from the consideration of the facts that the British consul in Alexandria, who selected it, must undoubtedly have been an adequate judge in this case; and that the fabrication of such a work by the ignorant and sluggish inhabitants of Thebes, and its Necropolis, would have been attended with greater difficulties, than the acquisition of many mummies from the catacombs.

Some mummies in the cabinet of Dresden, which have been described by Winckelman, corresponded generally with this; but had peculiarities not unworthy of notice. They were four in number; two only are particularly described, one a male, the other a female. The former had its bandages painted with the figure of a man in the prime of life, with a curled beard; his head enveloped with gilded bands, on which were represented precious stones. About the neck, a chain of gold was painted; various other ornaments in different parts, and the fingers were set off with rings. The feet and legs were naked, excepting that the former were covered with a kind of sandals. These appearances designate the body of a priest; for it is well known this order of men were most highly honoured by the Egyptians. They were the physicians, law-givers, and ministers of religion when alive, and on their death their bodies were treated with greater honours, and covered with more ornaments than others. The patera in the hand and the sandals on the feet, are especially appropriated to the mummies of the priests.

The most remarkable thing about this mummy is the inscription on the breast in Greek characters, *ΕΥΨΥΧΙ*. This inscription, or one very nearly like it, has been found in other places, as an epitaph or a valedictory address, or the conclusion to a letter; and appears to mean, Live happy! or perhaps in this instance, Be happy! The word is undoubtedly Greek, and a question arises, how it should come to be placed on the body of an Egyptian priest. Winckelman judiciously suggests that this might be the body of a Carian or Ionian, who had been naturalized in Egypt, and admitted to the mysteries of the priesthood; or is it not probable it might be intended to distinguish one of those Egyptians, whom king Psammetichus placed in the care of the

Ionians and Carians, settled in Egypt, for the purpose of having them thoroughly educated in the Greek language? These, when grown up, served as interpreters, and as some of them probably belonged to the order of priests, the inscription might be placed on the body as a mark of distinction for this kind of learning.

All other inscriptions on the coffins, the bandages and the papyri of the mummies, are pure Egyptian. The latter are generally, I believe, in the common or enchorial characters, the former in the sacred or hieroglyphic. In the last Quarterly Review may be found an account of these two kinds of writing. It appears that the Egyptians had two kinds of writing, one which was used for common purposes, and the other sacred. The former, being in most common use, has been denominated *enchorial*, from greek words signifying *in the country;* this is found in the manuscripts or papyri, deposited in the coffins of mummies, and appears, when compared with the other, to be a sort of running hand. The hieroglyphic or sacred characters were employed for sacred and mysterious subjects; for inscriptions in the temples, on the obelisks, and other monuments. The hieroglyphic writing is well known to be symbolical; the pictures of objects are by it made to represent words or ideas; but as it appears probable that in many instances the same idea is expressed by different objects, and different ideas by the same object, the true meaning being gathered from the connexion of these objects, this writing would be difficult to decypher even if we understood the ancient Egyptian tongue. The enchorial characters have by some of the learned been thought to be alphabetical, like the modern languages of Europe; but a more close examination shows that they are in many instances the same as the hieroglyphics, of course there is strong reason to believe, that the enchorial letters are derived from and are probably a corruption of the hieroglyphics. We have therefore no more reason to expect to succeed in decyphering these than the others.

The Rosetta stone, discovered by the French in Egypt, which fell into the hands of the English, and is now deposited in the British Museum, contains a triple inscription; that is, an inscription in three different kinds of characters, hieroglyphic, enchorial and greek. It has been ascertained, that these different inscriptions are intended to express the same ideas, of course they afford an opportunity of compar-

ing the two first with the last; and in this way the meaning of a considerable number of hieroglyphics has been satisfactorily made out. Among them are the names of deities, kings, animals, &c. A French author has gone so far as to give us an alphabet of Egyptian letters, both enchorial and hieroglyphic. Although these discoveries are calculated to afford much gratification to the learned, it is not probable that they will unfold to us any profound views of the literature and science of Egypt, as well for reasons hinted at above, as because all its writings, so far as we can judge, are very limited in the nature of their subjects.

The inscriptions on the cases of the Hospital mummy are altogether hieroglyphic.* They are placed in columns, to be read from above downward, and from right to left. No attempt has been made to decypher them, from the belief that with our present means this would be impracticable. But as the attention of the learned is very much excited by the discoveries already alluded to, and great efforts are now making to enlarge the bounds of the knowledge acquired, it is not improbable that before long, some part of these inscriptions may be understood, and their meaning unfolded to the public.

Inquiries have been made, whether this mummy had originally and natively the black colour it now possesses; and this has led to the general question, what was the national colour and race of the ancient Egyptians? The question is not easily answered. There are few points in which the authorities for opposite opinions are so strong and distinct. The writings of the Greek historians and poets are in support of the opinion, that the Egyptians were negroes; while the paintings, the sculptures, the mummies, and their appendages, lead to a very different conclusion. These discordant facts and authorities have caused a corresponding difference of opinions among modern writers; some of whom appear convinced that this nation were genuine negroes, and others consider the facts abundantly sufficient to prove that they had no alliance to the sable race of Africans.

At the head of the authorities in support of the opinion that the Egyptians were negroes, is to be placed the historian Herodotus, whose famous passage relating to this point

* I had supposed at first that some of them were enchorial; but am now satisfied that this is not the fact.

is generally known. After describing the expeditions of Sesostris, he makes a question, whether, when on his return, he left a part of his army on the river Phasis, at the eastern border of the Black sea, and settled a colony, from whom the Colchians were derived. For, says he, the Colchians appear to be Egyptians, and after mentioning some other reasons for his belief, he says it had occurred to him that this opinion was well founded, because the Colchians are of a "black colour and wooly haired." *μελαγχροες εἰσι καὶ οὐλότριχες*. Of course it would follow that the Egyptians were of a black colour and woolly haired; and in another instance he alludes to the blackness of their complexion.

In the learned work, entitled "Researches into the Physical History of Man," by Dr Prichard, the Greek authorities are collected in support of this hypothesis. From him it appears that, besides what has been cited from Herodotus, there are two passages in Æschylus, one in Pindar, and one in Lucian, which speak of the Egyptians as black coloured. The passage in Lucian does not, however, appear to go so far as he thinks; it is the description of a young Egyptian;—"besides being black, he had thick lips and was too slender in the legs, and that his hair and the curls bushed up behind, marked him to be of *servile rank*." We should infer that if these appearances marked him to be of servile rank, the better class of Egyptians had not these marks, which were considered to be distinguishing traits of a "servile rank." Then the better sort of Egyptians were not black, but there were among them persons of this colour who lived in the capacity of slaves. Such seems to me to be the meaning of the passage; but I leave to others to determine whether this be the most correct construction.

Independently of Lucian the authorities mentioned above seem to lead us irresistibly to the conclusion that the Egyptians were of the negro race; especially when it is noticed that there is not a single ancient author to favour a different hypothesis. This conclusion we should therefore adopt, were there not, on the other side, evidences of a different character, derived from monuments, temples, statues, sculptures, paintings, and the Egyptians themselves, as represented by their mummies.

In the publications of Winckelman, Denon, and others, especially in the great French work, "Description de l'Egypte," there are many hundreds of Egyptian figures of persons in every rank of life. Scarcely any of them bear the features of the African race. The great sphinx near

the pyramids is a remarkable exception; it is described by Denon and some others, as having the African character; but the head of the grand and majestic statue of Memnon has not the slightest mixture of the negro; and may serve as a contrast to the former. The other figures with a few exceptions, which will be noticed, are all European; the capitals of columns, the statues about the temples, the figures in the tombs, both those in fresco and bas relief, are of the same character. What is perhaps more remarkable, because more distinct, that the *painted* figures of Egyptians are of a red colour and not black. This alone would be a very strong reason for believing that the red colour and not the black, predominated among the Egyptians. But we are more forcibly impressed by this, on noticing, in a few instances, individuals of a black colour. Such are seen among the captives of king Psammis, mentioned already; those which I have noticed are generally represented in a state of inferiority or punishment. One has his hands tied behind him to a post; others are seen decapitated; but I have not noticed any blacks among the representatives of kings and heroes. The faces carved on the coffins of our mummy are red. We conclude that these blacks were either captives or slaves.

The most convincing description of facts must be derived from the mummies themselves. The characteristic marks of the head of the negro are well known and discriminated; the prominent jaws, low forehead, and compressed temples, are among the peculiarities of this race, not to be mistaken. Some writer has said that we ought not to expect to see the most strongly marked characters of the negro in the Egyptian, but rather a sort of transition head, intermediate to the European and African races. These would be singular negroes, with a red complexion and a form of head like the whites.

On examining the head of our mummy we found the jaws not prominent like the negroe's; the forehead not slanting and the breadth across the temples sufficiently ample. The remains of the hair are not woolly but strait, and of a yellow colour. A mummy at Roxbury, in the vicinity of Boston, belonging to Ward Nicholas Boylston, Esq. has a fine conformation of head. This was purchased by the possessor in Egypt and sent to England, where being opened at the custom house, it was so much exposed as to injure the covering, and the flesh has in a great measure decayed from the bones. The forehead is elevated and large, the jaws filled with fine teeth, not prominent, and the head altogether

of the European or Caucasian form. The two Egyptian skulls, represented by the distinguished Blumenbach in the Decades Craniorum, are also European*. The heads of the mummies in the "Description de l'Egypte" are drawn off nearly full size and with great distinctness. The complexion of these mummies is olive, the hair of the female is long, flowing, and handsomely arranged; that of the male is very much in the style of the hair of Roman heads; and the whole character of the head and face is more Roman than African. The most general and decisive facts are those stated by the celebrated Cuvier. "I have examined in Paris and in the various collections of Europe more than fifty heads of mummies, and not one among them presented the characters of the negro or the hottentot." We have therefore no difficulty in concluding that this celebrated people were not negroes, that the configuration of their heads was European, and their skin of a red colour, like that of the Hindoos. The few instances of black figure and formation are the representations of slaves or prisoners, brought to Egypt, as at the present day from the interior of Africa. The modern population of Egypt consists principally, it is well known, of Arabs, Turks, and of the swarthy Copts, the supposed descendants of the ancient Egyptians, with a small number of black slaves.

The antiquity of this mummy may be a subject of curious speculation, but we are not to expect to arrive at any very precise conclusions in regard to it, till the characters on the sarcophagi have been decyphered. In the beginning of this paper it has appeared that the operation of embalming was performed at a very early period of Egyptian history, earlier, than the era of the construction of the pyramids, and there can be no question it was continued until the conquest of Egypt by Cambyses. From the foundation of the monarchy by Menes or Misraim the son of Ham to the time of this conquest is about eighteen hundred years. The practice of embalming was perfectly established when Joseph

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* Blumenbach made a singular discovery in regard to the incisor teeth of some mummies. He says that the crown of their teeth instead of being sharp is thick like a truncated cone; and that the crowns of the canine teeth are like those of the grinders. Such forms, if it is pretended they are original, are contrary to all example and analogy. The incisor teeth of some of the natives of the South Sea Islands are filed so as to be pointed; and in many heads of those people, as well as in the aboriginals of our own country, the incisors, being worn down by long use, present the appearance described by Blumenbach.

was in Egypt, in the year of the world 2262, that is six hundred years after the foundation of the monarchy; and it is fair to suppose, that it might have been in use three hundred years, that is, half the term from the first king to that time. In this way we shall get the number of about fifteen hundred years, as the term of the existence of this practice down to the Persian conquest. Some modern authors have believed that at that time a change was made in the national customs, that the use of embalming, and even the worship of their gods were totally abolished. The last opinion is evidently not well founded, since not only the Greeks adopted the Egyptian deities before and after the conquest by Alexander; but the Romans, it is well known, took a large number of Egyptian gods into their mythology, and some of them were treated with distinguished favour. Whether as much can be said of the preservation of the dead appears to me very doubtful. Winckelman is strongly inclined to the affirmative opinion, and quotes not only Herodotus, but Diodorus Siculus and Lucian, in support of his hypothesis. The two former, in speaking on this subject, employ the present time, as if the custom were actually existing; but it may be noticed that this form of expression is frequently used by them in the relation of customs which must have ceased to exist; as for example in the part of Diodorus, immediately preceding the passage where he describes the operation of embalming; he speaks of the Egyptians as actually paying divine honours to their kings, when in fact it is probable there were no kings existing in Egypt at the time he was there. For he was in that country, as well as we can judge, in the time of Julius Cæsar or of Augustus; before whom Egypt had been repeatedly in the possession of the Romans, and it does not appear that the shadows of kings set up by this people still existed; or if they did, it is not probable they were treated "as partakers of the divine nature, the sources of the greatest benefits*." Winckelman also cites a passage from St Athanasius to this effect, that "in Egypt they had the practice of enveloping the bodies of pious men in bandages, and especially the martyrs, and of keeping them in their houses, as the Egyptians had done." It appears quite as probable, that the custom alluded to is rather that which was practised by the Jews and the early Christians, of simply swathing the bodies in bandages; otherwise we

* V. D. Siculus, p. 101. Ed. Wesselingii.

should have had a more frequent and distinct mention of so remarkable a practice in the works of the fathers of the church. On the whole, it seems probable, that the use of embalming was in a great measure broken up by the Persian power, at the period of the conquest, although it might have been occasionally employed to a much later day.

The paintings and inscriptions on the sarcophagi of the mummy belonging to the Hospital, with all their accompaniment of bandages, sycamore wood, and sacred beetles, are in the purest Egyptian style; and although their fine condition prevents us from referring it to the earliest times, it was probably embalmed before the Persian conquest, or between this period and that of the acquisition of Egypt by the Macedonians.

In adverting to the different topics, which have seemed to be connected with the original subject of inquiry, I have been led into details not at first contemplated. The remains of ancient Egypt are like the ruins of another world, and excite the most profound interest as well from their antiquity as their unparallelled magnificence and sublimity. All that relates to a people who could erect such works, and with science so inadequate as we suppose them to have possessed, is wonderful: yet scarcely more so than that the very individual artificers should be brought down in person to the present age. If we could for a short time bring back the spirit which once animated, and, according to the Egyptian doctrine, still inhabits these bodies, what wonders would be revealed; but unless such a miracle were to happen, we, and the generations that follow us, will be compelled to look to a different state of existence to unfold the arts, the sciences, the history, and the religion of this mysterious nation.

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## Art. XXXIII.—*Description of Mr. Perkins's New Steam-Engine, and of the application of his Invention to Engines of the Old Construction.* [*Edin. Phil. Jour.*]

We have already communicated to our readers in the two last Numbers of this Journal, all the authentic information which we could obtain respecting Mr Perkins's new Steam-Engine; and we have used the utmost diligence to obtain such farther information as may, in some measure, gratify

that curiosity which these imperfect notices have excited. There never has been in our day an invention which has created such a sensation in the scientific and in the manufacturing world. The steam-engine of Mr Watt had been so long considered as the greatest triumph of art and science, that it was deemed a sort of heresy to regard it as capable of improvement; and, notwithstanding all that has been done by Mr Woolff, and other eminent engineers, the undoubted merit of their engines has scarcely yet been admitted by the public. Under such circumstances, Mr Perkins's claims were likely to meet with various kinds of opposition. Instead of hailing it as an invention which was to do honour to the age in which we live, and to add a new and powerful arm to British industry, imperfect experiments and confined views were urged against the principle of its construction, the jealousies of rival traders were arrayed against it, imaginary apprehensions of danger were excited, and short-sighted politicians sounded the alarm, that such an invention would precipitate our country from its lofty preeminence among the manufacturing nations of the world.

Most of these grounds of opposition have been now removed by direct experiment. Mr Perkins's engine is actually at work. Its operations have been witnessed, and minutely examined by engineers and philosophers of all kinds; and the most unreasonable sceptics have been compelled to acknowledge the justness of its principles, as well as the energy of its operations. The active and inventive mind of Mr Perkins, however, did not remain satisfied with this experiment. He has discovered a method, which we consider equal in value to his new engine, by which he can convey the benefit of his original principle to steam-engines of the old construction; and this has been recently succeeded, we are told, by a most extraordinary discovery, that the same heat may be made to perform its part more than once, in the active operations of the engine.

In order to convey to our reader some idea of these great inventions, we have obtained a drawing, made by M. Montgolfier *jun.*, and given in Plate III. which, though it does not represent the actual machine, yet contains such a view of its parts as is necessary for understanding its principle.

The generator, which supplies the place of the boiler in ordinary steam-engines, is a cylinder ABCD, made of gunmetal, which is more tenacious, and less liable to oxidation, than any other. The metal is about three inches thick; and the vessel, containing eight gallons of water, is closed at

both ends, with the exception of the five openings for tubes, shewn in the figure. The generator is placed vertically in a cylindrical furnace EF, whose chimney is G, the heat being sustained by a pair of bellows H, wrought by the engine, and conveying its blast in the direction IK to F. A heat of from 400° to 450° of Fahrenheit is thus applied to the generator, which is entirely filled with water. The valves in the tubes *m*, *n*, which are steel cylinders working in hollow steel pipes, are loaded, the one with 37, and the other with 35 atmospheres; so that none of them can rise till the heat creates a force greater than the least of these weights.

Let us now suppose, that, by means of the compressing pump L, whose handle M is wrought by the engine, water is forced into the generator; this opens the valve above *n*, loaded with 35 atmospheres, and instantly a portion of the heated and compressed water *flashes* out in the form of steam of high elasticity, and of a temperature of 420°; and communicating by the steam-pipe 2, 2, 2, with the valve-box V, it enters the cylinder PP, lying horizontally, and gives motion to its piston PQ, which performs 200 strokes in a minute, and drives a crank R, which gives a rotatory motion to a fly-wheel, as seen in the figure*. When the eduction-valve is opened, the steam, after having produced its stroke, is carried by the eduction-pipe 3, 3, 3, into the condenser STXV, where it is condensed into water at a temperature of about 320°, and under a pressure of 5 atmospheres; from thence, by the pipe 6, 6, 6, it is drawn into the pump L, whence it is forced along the pipe 4, 4, 4, to the generator, thus performing a complete circuit.

The forcing-pump acts with a pressure exceeding 35 atmospheres; consequently, when the water received in it from the condenser is urged into the generator, it must expel a portion equal to itself in volume: this portion, as above described, flashes instantly into highly elastic steam. The forcing-pump, too, is so contrived as to act with a steady force, and, consequently, the expelled water must be driven from the generator in a steady current, and thus steam of a constant elasticity is supplied to produce the power.

Some philosophers are of opinion, that the heat of the portion of water which escapes, is of itself sufficient to main-

* The parallel motion represented at PQ, is not the correct one used by Mr Perkins. The piston-rod is connected by a flexible joint, with a sort of carriage with four wheels at each end, and working in a strong horizontal box of steel.

tain the steam at that high degree of heat and elasticity with which it reaches the piston; and, consequently, that this engine is nothing more than a High Pressure Engine. Other persons, however, have supposed, and we confess we are among that number, that the portion of water which escapes, must necessarily carry off a quantity of heat from the adjoining stratum (the temperature of which *may be* thus reduced below the freezing point). But it is more likely, that, in virtue of some new law of the transmission of heat under the combined conditions of elevated temperature and high pressure, while the water, also, is forced to remain in contact with the red hot generator, the whole water in the boiler may be laid under requisition to furnish the discharged fluid with its necessary supply of caloric.

It is almost unnecessary to state, that the motion of the engine is produced by the difference in elasticity between the steam pressing on one side of the piston and that pressing on the other. In the first case, the steam recently produced, acts with a force, say of 500 lb. on the square inch, while that on the weak side, or that communicating with the condenser, acts with only 70, the difference, or 430 lb., being the true power gained.

When there is a surplus of water in the generator, occasioned either by working the forcing pump too violently, or by too vehement a heat, the water will escape by the tube *m* with a valve above, loaded with 37 atmospheres, and will pass by the pipe 5, 5, 5, into the condenser STXV.

In order to explain the ingenious manner in which the pipe 4, 4, 4, supplies the generator with water, we must observe that this pipe communicates with the pump L, which is wrought by the engine. This pump draws the water by the pipe 6, 6, 6, from the condenser STXV, and returns it by the pipe 4, 4, 4; that is to say, when the handle M is drawn up, the water rushes into the cylinder of the forcing pump, through a valve in the pipe 6, 6, 6, opening *into* that cylinder: This valve, of course, instantly closes when the downward stroke of the pump is made, and the water now escapes through a valve opening *outwards*, along 4, 4, 4; thus effectually cutting off all direct or uninterrupted communication between the generator and the condenser. In order to keep the water in the condenser at a pressure of five atmospheres, the blast of the bellows H goes round the condenser STXV; but, when it is not sufficient for this purpose, cold water is introduced from the reservoir Z, by means of the pipe 7, 7, 7, loaded with five atmospheres.

From the high elasticity of the steam employed in this engine, it has been supposed to be very liable to explosion. This, however, is a vulgar error. Since there is no reservoir of steam exposing a large surface to its expansive force, as in the common high pressure engines, the steam being generated only in sufficient quantity to produce each succeeding stroke of the piston, the ordinary source of danger is entirely removed. But, in order to take away all apprehensions on that subject, the induction pipe 2, 2, 2, in which the steam is actually generated, is made so strong as to sustain an internal force of *four thousand* pounds on the square inch, which is *eight* times more powerful than the actual pressure, viz. 500 pounds on the square inch, with which the engine works. This enormous superabundance of strength is still farther secured by means of the safety-pipe 8, 8, 8, provided with a thin copper "safety-bulb" *a b*, which is made so as to burst at a pressure of 1000 pounds on the square inch. In order to satisfy his friends on this very important point, Mr Perkins has repeatedly urged the power of the steam to such a degree as to burst the copper bulb in their presence. This tube merely rends, or is torn asunder like a piece of paper, and occasions no injury either to the spectators, or to the apparatus; so that we have no hesitation in considering this engine, notwithstanding its tremendous energies, much more safe in its operations than even the common low pressure engine.

The safety tube 8, 8, 8, communicates also with the indicator *c d*, having a dial-plate *c e*, and an index *e f*, which, by means of a suitable contrivance at *v*, *v*, indicates the pressure or number of atmospheres with which the engine is working.

The cylinder and piston PPQ, have been separated from the rest of the engine, for the sake of distinctness. Their proper position, however, will be understood by supposing the four lines 9,9; 9,9 to coincide.

The engine which we have now described, is at present performing actual work in Mr Perkins's manufactory. It is calculated as equal to a ten-horse power, though the cylinder is no more than 2 inches in diameter, and 18 inches long, with a stroke of only 12 inches. Although the space occupied by the engine is not greater than 6 feet by 8, yet Mr Perkins considers that the apparatus (with the exception of the working cylinder PP, and piston PQ,) is perfectly sufficient for a 30-horse engine. When the engine performs full work, it consumes only *two* bushels of coal in the day.

## *On the application of Mr Perkins's principle to Steam-Engines of the old Construction.*

Great as the invention is which we have now described, yet we are disposed to think that the application of the principle to old steam-engines is not less important*. When we consider the enormous capital which is at present embodied in Great Britain in the substantial form of steam-engines, and the admirable elegance and skill with which these noble machines impel and regulate the vast population of wheels and pinions over which they reign, we feel as if some vast innovation were proposed upon our established usages, by the introduction of Mr Perkins's engine. The very idea that these potentates of the mechanical world should be displaced from their thrones; that their strongholds should be dismantled; their palaces demolished, and their whole affairs placed under a more economical management, is somewhat startling to those who dread change, and admire institutions that both work and wear well. Mr Perkins, however, has saved them from such a degradation. He has allowed them to retain all their honours and privileges, and proposes only to invigorate them with fresh influence and power.

In this new system, *the old engines, with their boilers, are retained unaltered.* The furnaces alone are removed. Mr Perkins constructs a generator consisting of three horizontal tubes of gun-metal, connected together, filled with water, and supplied with water from a forcing-pump, as in his own engine. This generator is exposed to heat in an analogous manner, so that, by means of a loaded valve, which opens and shuts, the red hot fluid may be constrained till forced out of the generator into the water in the boilers of Bolton and Watt. By this means, as much low pressure steam of four pounds on the square inch may be generated by *one* bushel of coals, as could be produced in the old engine by *nine* bushels. This most important result, was obtained by actual experiment.

Since these great improvements have been effected, Mr Perkins has made a discovery that seems, in its practical

* This invention appears to have been fully established by direct experiment, whereas the *new engine*, with all its great promise, is still only undergoing trial.

importance, to surpass them all. He now entirely dispenses with the use of the condenser, and works the engine against the atmosphere alone; and by methods with which we are not acquainted, and which indeed it would not be prudent for him to disclose at present, he is enabled *to arrest the heat after it has performed its mechanical functions, and actually pump it back to the generator, to unite with a fresh portion of water, and renew its useful labours.* In an operation like this, a considerable portion of the heat must still be lost, but the wonder is that any should be saved; and we venture to say, that the most sanguine speculator on the omnipotence of the steam-engine, never dared even to imagine the possibility of such an invention.

We are well aware, that, in announcing this discovery, we are exposing ourselves to the criticisms of those whose belief is naturally limited by their own experience; but it is satisfactory to know, that Captain Basil Hall, (whose account of Mr Perkins's discoveries and inventions, as delivered before the Royal Society of Edinburgh, gave such universal satisfaction,) has been entrusted with Mr Perkins's discovery, and that he speaks confidently of the soundness of its principles, as well as the practicability of its application*.

We cannot quit this subject, without congratulating the country on the brilliant prospects with which these inventions promise to invest all our national concerns. At any period of the history of British industry, they must have excited the highest expectations; but, originating as they have done, when our commerce, our manufactures, and our agriculture, the three stars of our national prosperity, have just passed the lowest point of their orbit, and quitted, we trust for long, the scene of their disturbing forces, we cannot but hail them with the liveliest enthusiasm, and regard them as contributing, to ensure the preeminence of our industry, to augment the wealth and resources of the nation, and, by giving employment to idle hands, and direction to idle minds, to secure the integrity and the permanence of our national institutions†.

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* After the 10th June, Mr Perkins, whose address is Perkins and Company, 41, Water Lane, Fleet Street, is ready to take orders for his New Engines, and his apparatus for producing low pressure steam for working the ordinary engines. The price, we believe, of the new engine, is only half that of Bolton and Watt's, with *one-third* of the savings of fuel for a period of years, which we have not heard stated.

† It is due to the truth and candour of philosophical history, to mention,

## *Remarks on the Preceding Account.*

(By the Editors of the Boston Journal.)

No account of the late celebrated invention of Mr Perkins, written by that gentleman himself, having yet reached us, we have extracted the above from the Edinburgh Journal although it has been already reprinted in several of the newspapers. It will be perceived that the engine here described, differs from the common condensing or low pressure engine, in being calculated for steam of great elastic force, and from the common high pressure engine, in being furnished with a condensing apparatus. Another essential characteristic of this machine is, that the generator or boiler is used *full* of water and the steam formed in the induction pipe, which, in this view, may be considered as part of the cavity of the cylinder; whereas, in all other engines the steam is formed in the boiler itself, a space being left for that purpose immediately above the water.

There is a peculiarity in the condensation of the steam, well worthy of notice. It will be remembered, that the condenser of the common engine is a vessel in which a vacuum is constantly maintained; the steam which passes into it being condensed by cold water, and the atmospheric air which is extricated from the water by boiling and passes over with the steam, being drawn out from the condenser by an air pump worked by the engine. In the condenser of Mr Perkins's engine, it seems no vacuum is formed, but, on the contrary, it is filled with steam, or perhaps air, and with water of the temperature of 320°, and therefore capable of forming steam of at least 70 lb. per inch elastic force. On opening the communication between the cylinder and the condenser after each stroke of the engine, so much of the steam in the cylinder, which it will be remembered has an elastic force greatly exceeding 70 lb. per inch, rushes into the condenser as is sufficient to reduce the force of the remaining quantity to 70 lb. per inch; and this also is driven into the condenser by the returning piston. This new supply of steam to the condenser is there either deposited, in the form of water, or causes the deposition of a volume equal to itself of the steam

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that Mr Perkins is not our countryman; but the age of jealousy against America has happily gone past, and we hail, with sinceré pleasure, any circumstance which contributes to the scientific renown of our great descendants, and companions in freedom and intelligence.

already in the condenser. This follows from the fact* that the density of steam bears a relation to its elastic force; conquently, an increase of density beyond that answering to the elasticity supported by the temperature of the condenser, must be followed by such deposition. This form of apparatus and mode of working, frees the engine from the air pump and its appendages, as all the permanently elastic fluid derived from the boiling water can escape by the valve in the pipe 7, through which it must be driven whenever, by accumulating, its elastic force exceeds 5 atmospheres; and the water formed by the condensation of the steam is again returned to the generator by the forcing pump.

There is to us, something so inexplicable in the formation of the steam in the cylinder or induction pipe, that were the evidence of the actual performance of the engine less full and clear, we should doubt whether it would take place in the manner stated. A small portion of cold water being driven into the generator, forces an equal portion of the heated and compressed water contained in that vessel to pass the valve above *n*, where it *flashes* into steam. The fact that a great quantity of heat is required by water to enable it to pass from the liquid to the vaporous form, is familiar to every one. Whence then, in the present case, can this caloric for the supply of latent heat be derived? It seems to us, that the only possible way in which it can be supplied, is indeed from "the operation of some new law," as stated in the preceding account, by which "the whole water in the boiler is laid under requisition." Yet there are mechanical obstacles in this case to the operation of such a law, if it exists, which would seem insuperable; for the valves above *m* and *n* are loaded, the first with 37 and the second with 35 atmospheres. Now, water being injected into the generator, the valve above *n* is raised by the heated water which is displaced by the injection. Let us suppose the first atom of this water which passes the valve *n*, to be instantly formed into steam having an elastic force of but 3 atmospheres. This steam acting against the loaded piston in one direction, reacts upon the upper side of the valve with its whole force. The load of the valve at *n* is now 38 atmospheres, whereas that at *m* is but 37. We should now suppose that the valve at *n* would close and the remainder of the water to be ejected, would pass through *m*. Could we even suppose a sufficient quan-

* See Robison's Mechanical Philosophy, Art. Steam Engine.

tity of water for the formation of a full cylinder of steam, were to pass the valve *n* before any portion of it assumed the vaporous form, we have another and equal difficulty: as in this case, on the formation of the first inch of steam, the valve being closed by the expansion of this steam, as in the preceding instance, the communication between the water above the valve, not formed into steam, and that in the generator, is interrupted, and the required heat can only be transmitted slowly, as it must be conducted through the substance of the valve.

It is worthy of remark, that no loaded valve or mercurial gauge is represented in the drawing, by which the force of the steam in the induction pipe or under the piston can be ascertained. For the valves above *m* and *n*, and the index *e f*, show merely the force with which the injecting pump is worked, and cannot indicate at all, the elastic force of the steam as it is formed, and it will be perceived, by reference to the plate, that the valves *m* or *n*, may be raised, or the safety bulb *a b*, rent, simply by the injection of cold water. Some apparatus to determine the actual force of the steam formed, would have been the more satisfactory, as no preceding experiments, of which we have been able to find any notice, have assigned a force of 500 lb. per inch area to steam of 420° Fah., the temperature which the steam in this engine is said to possess*. Direct experiments to ascertain the important fact of the elastic force of steam, have not, we believe, been made at temperatures higher than 320°; and although the law by which the force is increased as the temperature is elevated, has not been expressed in any formula so accurately as to deserve perfect confidence when carried far beyond the limits of experiment, yet a mere inspection of the numbers representing the forces of different temperatures, as found by experiment, show such a relation between them that it appears easy to assign, without any great error, the force for a temperature a little beyond those at which experiments have been made.

Of the several formulas which we have seen, that of Mr Creighton, of Soho†, gives the most rapid increase of elastic force as the temperature ascends. Thus the elastic force

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* Mr Evans, indeed, assigns it even a higher force. But his conclusions are founded on the presumption that the force of steam increases in a geometrical progression, its temperature being increased in arithmetical. This, considering Fahrenheit's scale as measuring equal increments of heat, is manifestly contradicted by all experiments.

† Tilloch's Magazine, vol. 53, p. 266.

for 300°, will be found from Mr Creighton's formula equal to a column of mercury 142 inches high. Dr Ure*, whose experiments, compared with others, gave remarkably high forces, found the force for the same temperature 139 inches, and Mr P. Taylor† found it but 133 inches.

We find, however, that even Mr Creighton's rule gives steam of 420°, an elastic force equal to only 723 inches of mercury, or 361 lb. nearly, on each square inch. The same rule determines the force of steam of 320°, to be 192 inches or 96 lb. per inch area. This exceeds that assigned for the same temperature in the preceding account. If these numbers truly represent the forces at the stated temperatures of the steam on the opposite sides of the piston of Mr Perkins's engine, the actual force of the stroke would be 265 lb. on each inch of the piston, instead of 430 lb. as stated in the Edinburgh Journal‡.

We had supposed, heretofore, that whatever advantages were to be derived from this invention, they would in some way or other be referable to "high steam;" but this, it appears from the second part of the account, is not true in fact. For, from this, the corner stone of the edifice is in the mode of forming the steam, or rather, in the circumstances under which the water is placed when heating, and it seems that heat may be transmitted much more perfectly to water in vessels full of that fluid, than it can be when the vessels are partly filled with steam. The difference being as nine to one in favour of the former condition. This important discovery is applicable to other purposes than the steam-engine, and we perceive that Mr Perkins has already taken a patent founded, we presume, upon it for heating rooms.

The only circumstance in which water in the common engine boiler, can differ from the same fluid in close tubes, to which Mr Perkins proposes to apply the fire, appears to be this: the steam formed at the bottom of the common boiler, is constantly rising through the water to the space

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* Dict. of Chem. art. Caloric.

† Tilloch's Magazine, vol. 60, p. 453.

‡ Biot Traitè de Physique tome 1, p. 531, states the force for 130° Centegrade, equal to 266° Fah. at 75 inches. Creighton's formula, for the same temperature, gives 82 inches. Biot thought his method unworthy of confidence at temperatures higher than 130 cent. and it is right to notice his observation; that such formulas are never any thing more than approximations. By Dr Ure's method of calculating, the elastic force for 420° Fah. amounts to no more than 361 inches: about half the amount given from Mr Creighton.

assigned it in the upper part of the vessel; whereas in close tubes *full* of water, no steam being formed, very little internal action takes place. These two conditions appear to be precisely those of water when boiling, and of water merely heating, at a temperature below the boiling point. Thus the advantages of Mr Perkins's method seem to depend on this: that water placed over a fire without being suffered to boil, will receive more heat in a given time, than it can receive when in a state of ebullition. Now according to one of the experiments of Dr Black*, a heat which raised water from 50° to the boiling point, in 4 minutes, caused it all to boil off by being continued 20 minutes longer; and from the experiments of Mr Watt† four parts of steam, of the temperature of 212°, will raise at least 20 parts of water, from 50°, to the boiling point. If we connect these experiments together, we find that the water receives heat from a given fire with the same rapidity before it begins to boil, and while boiling. For in Dr Black's experiment, say an ounce of water, not in a boiling state, was heated 162° in 4 minutes, it then began to boil, when according to Mr Watt, the steam formed in each succeeding 4 minutes, contained heat enough to raise the temperature of another ounce of water, 162°. We should think it difficult to reconcile the facts apparently established by these experiments, with that of any great saving of fuel from the use of the tubes of Mr Perkins. Yet, from the confident manner in which it is asserted, that such saving has been proved, we certainly are not permitted to doubt it‡. T.

## General Intelligence.

*New Work on Crystallography.*—We have just received a copy of Mr Brooke's new work, entitled, " A Familiar Intro-

* Black's Lectures, vol. I, p. 151.

† Thomson's Chemistry, vol. 1, p. 101, and Black's Lectures, vol. 1, p. 166.

‡ The deposition of salts, which, forming a crust on the surface of the common boiler, prevent the free transmission of heat, would not probably take place in the tubes of Mr Perkins. This however does not appear to have been considered as of any striking advantage, not being mentioned in the account.

duction to Crystallography, including an explanation of the principle and use of the goniometer. With an Appendix, containing the mathematical relations of crystals; rules for drawing their figures; and an alphabetical arrangement of minerals, their synonymes, and primary forms. Illustrated by nearly 400 engravings on wood. By Henry James Brooke, F. R. S. &c." This work is peculiarly adapted to the use of students in mineralogy, and will be found exceedingly valuable. The first part is devoted to the definitions of the terms employed in the description of crystals, which are given in a peculiarly distinct and intelligible manner, and are amply illustrated by diagrams. The principle upon which the reflective goniometer of Dr Wollaston is constructed, and the application of this elegant instrument are so fully and clearly explained, that the opinion of its use being attended with difficulty is wholly removed. In rendering the first part of his work quite elementary, Mr Brooke has enabled the young mineralogist, even if unacquainted with the rudiments of geometry, to make very considerable advances in the science of crystallography. Those who are not in the habit of mathematical investigations, and who cannot avail themselves of the theory of decrements in tracing the relation between the secondary and primary forms of crystals, will derive great assistance from the "tables of modifications of the primary forms" in the eleventh section. These will enable them to compare all the classes of simple secondary forms with each other, and with their respective primary forms, and will present a general view of all the known classes of the primary.

The 14th section contains a full explanation of the symbols used in the description of the secondary forms of crystals, and of the method of applying them.

In the Appendix Mr Brooke has given an outline of the method of applying the theory of decrements to determine the relations between the secondary and primary forms, and of calculating the laws of decrement. In these calcutions he has substituted spherical for plane trigonometry.—[J. W. W.]

*Phillips's Mineralogy.*—We learn with pleasure that the third edition of Mr Phillips's work on mineralogy is to be republished in this country with an appendix, by Mr J. Griscom, containing the localities of American minerals. Mineralogists throughout the country will, we trust, forward to Mr Griscom, as requested in his circular letter, early no-

tices of new localities. The work of Mr Phillips is a companion to that of Mr Brooke.—[J. W. W.]

*Composition for sheathing the bottoms of vessels, roofing the tops of houses, &c.*—A patent has been obtained in England for a metallic composition to be formed into plates, applicable to the covering of ships' bottoms, and the roofing of houses, or any places subject to the action of sea-water, the air, or of the weather generally. These plates are composed of tin, lead, and zinc. A certain quantity of lead is to be first melted, to which twice that quantity of tin is to be added; this composition is cast into small lumps of any convenient size, and the lumps are added to three times the quantity of zinc melted in a distinct vessel. The mixture is cast into cakes about eight inches broad, ten inches long, and three-quarters of an inch thick. These cakes are afterwards to be rolled or hammered out into plates.—[*See Lond. Journ. No.* 30.]

*Method of obtaining Iron from Slags and Cinders.*—A patent has been taken out in England for a mode of extracting pure metal from the slags or refuse of iron produced by its ordinary working. The process consists in reducing the slag to small pieces, and then mixing it with certain quantities of *fluate of lime;* the proportions must depend upon the quality of the slag, but about five or six parts of the lime will generally answer. The mixture is to be moistened with water, in order to bring the parts into more immediate contact. It is then to be treated in the usual manner, and the fusion continued or repeated according to the purity of the slag. The iron obtained is said to be of excellent quality.

*Matrix of the Diamond.*—Mr Heuland, in a letter to the Geological Society of London has described two specimens, the first of which is a conglomerate of oxide of iron, with small waterworn quartz pebbles, containing a diamond. This, which is termed in South America *Cascálhao*, Mr Heuland considers of alluvial origin. The other specimen, from Pereira in Brazil, is a very small brilliant dodecahedral diamond, surrounded by skorodite or cupreous arseniate of iron, in a gangue or matrix of massive oxide of iron (Werner's brown-iron-stone.) This oxide of iron forms veins or beds, 25 feet deep, resting on chlorite slate, in the mountains near Pereira. That it is the true matrix of at least the Brazilian diamond, appears confirmed by the locality where diamonds have not before been discovered, by its being accompanied by the arseniate of copper, and

by the difference of this oxide of iron from that in the *Cascálhao*, which is neither earthy, granular, or in water-worn particles.—[*Philos. Mag.*]

*Wernerian Society.*—At a late meeting of the Wernerian Natural History Society of Edinburgh, Professor Jameson read an account of a remarkable thunder storm in Scotland, in the course of which all surrounding objects assumed the colour of copper. He also laid before the society the skeleton and stuffed skin of the Dugong of Singapour, an animal allied to the porpoise, and which, when it raises its head and upper extremities, containing protuberant mammæ, above the water, may probably have given rise to the fable of the Indian mermaid.—[*Ed. Philos. Jour.*]

*Discovery of a New Alphabet.*—The Gazette of Bombay contains an account of the late discovery of an alphabet in the east, which gives a key to the ancient inscriptions found in the caverns of India, and consecrated in the religion of India, such as those of Elephanta, Keneri, &c. It may be hoped also by this means to learn their signification, their dates, their usage, and origin.—[*Rev. Ency. No.* 50, *p.* 397.]

*Land Slip.*]—On the 28th of August, about three o'clock in the afternoon, the inhabitants of the village Hayotte, in the parish of Champlain (L. C.) were alarmed by the following extraordinary occurrence: A tract of land containing a superficies of 207 arpents (166 acres) was suddenly moved from a distance of 5 or 6 arpents (about 360 yards) from the water's edge, and precipitated into the river Champlain, overwhelming in its progress barns, houses, trees, and whatever else lay in its course. The earth thus removed dammed up the river for a distance of 26 arpents. The effect was instantaneous, and accompanied by an appalling sound; a dense vapour, as of pitch and sulphur filled the atmosphere, oppressing those who witnessed this awful convulsion almost to suffocation. A man who was on the ground at the time, was removed with it to a considerable distance, and buried up to the neck; he was extricated from his perilous situation without sustaining any serious injury.—[*Quebec Gazette.*]

*Plants from Rio Janeiro.*—The Botanic Garden, at Cambridge, has been enriched with a valuable donation from George Brown, Esq. of Beverly, consisting of three large boxes of plants obtained by him from the Royal gardens at Rio Janeiro, among which are the Artocarpus or bread fruit; the Cinnamon; the Camphor-tree; the Clove; the Black Pepper; Crinunus, a new yam from Angola; a seedless va-

riety of the Orange; the Lime-tree; several species of Epidendrum and Tillandsia; together with several bulbs, not yet known.

Mr Brown has also presented a very extensive and interesting collection of seeds, and has offered to obtain for the garden any Brazilian seeds which may be requested.

*Sordawalite.*—M. G. Nordenskiold, Esq. has given the name Sordawalite to a mineral from Finland. It has a greenish or greyish black colour, and is somewhat like coal in appearance. It resembles the black garnet of Lapland, and was regarded as massive melanite.

It is as hard as glass, with a conchoidal fracture, and vitreous lustre inclining to semi-metallic. It is opaque and brittle. Spec. grav. 2.530.

On long exposure to the atmosphere it becomes reddish.
Occurs in primitive country.
Is partly soluble in muriatic acid.
It is composed of

| | |
|---|---|
| Silica | 49.40 |
| Alumina | 13.80 |
| Peroxide of iron | 18.17 |
| Magnesia | 10.67 |
| Phosphoric Acid | 2.68 |
| Water | 4.38 |
| | 99.10 |

*Achmite.*—Berzelius has given the name Achmite (from ακμη, *a point*) to a new and very remarkable substance from Egen, in the south of Norway. It is found crystallized in nodules of quartz, disposed in granite, and the crystals appear to radiate from the granite, into the quartz. Externally it has a dark brown colour, inclining to red, and in the fracture greenish-black. It is feebly translucent, and scratches glass. Its specific gravity is 3.24. Its form is a rhomboidal prism, with truncated edges and very acute summits.

It melts before the blowpipe into a black globule.
According to the analysis of Berzelius, it contains

| | |
|---|---|
| Silica | 55.25 |
| Oxide of Iron | 31.20 |
| Oxide of Manganese | 1.08 |
| Lime | 0.72 |
| Soda | 10.40 |
| | 98.65 |

(Continued from p. 204.)

Art. XXXIV.—*Remarks on the Increase of the Population of the United States, and Territories of North America, with Original Tables, deduced from the American Population Returns, to illustrate the various Rates of Increase in the White Population and Slaves, and also the comparative degrees in which Agriculture, Commerce, and Manufactures prevail.* By George Harvey, Esq. Member of the Astronomical Society, &c. Communicated by the Author. [*Edin. Phil. Jour.*]

## Slave Population.

Every lover of humanity necessarily feels an interest in the condition of that class of our fellow men who are doomed to spend the long range of a miserable existence in a state of slavery. The heart sympathises with their misfortunes, and we eagerly embrace every opportunity, which is likely to throw even but a feeble and uncertain light on their unhappy condition. The returns of the slaves contained in the American Population Tables, are probably the *only* sources from which any satisfactory information can be drawn, to illustrate this very important subject.

It has been already remarked, that in the enumerations of the American people, prior to the census of 1820, the slaves were thrown into one mass, without any distinction as to their sexes, and much less any divisions relating to their ages. In the census of 1820, however, these very important particulars were attended to; the males being separated from the females, and each sex divided into the four classes alluded to at the commencement of the paper. It was observed also, at the same time, as a circumstance much to be regretted, that the ages of the slaves do not entirely correspond with the classes into which the free males and females were divided; and that, therefore, many interesting comparisons which might otherwise have been made, with the white part of the population, could not, under the present circumstances, be instituted. It would have been interesting, for example, to have been enabled to compare the slave population under ten years of age, with the free white population of the same

class, and by this means to have considered, how far the general circumstances of the younger classes of slaves at all assimilate to the state of the free American population of corresponding ages; whether slavery exerts any influence of a very baneful nature on the young; and whether the freedom of the parent does not contribute, in a very powerful degree, to cherish a healthy and vigorous offspring. Some idea of the nature of this influence may be drawn from a Table which will speedily follow. Two classes, however, of the slave population, admit of a direct comparison with the free population; that is, those of twenty-six and under forty-five, and of forty-five and upwards. If, indeed, we regard the aggregate of the classes below the former of these, in each case, as a single class, another comparison may be made, with each sex, below the age of twenty-six.

If we take the total amount of each class of the free white population, in all the provinces, in 1820, it appears, that, for every 100 free white males of 26 and under 45, there were 354 under 26 years of age, and 65 of 45 and upwards; but that for every 100 male slaves of 26 and under 45, there were 334 under 26 years of age, and only 47 of 45 years and upwards. So also, for every 100 free females of 26 and under 45, there were 362 under 26, but only 63 of 45 years and upwards; and for every 100 female slaves of 26 and under 45, there were 345 under 26 years of age, and 46 of 45 years and upwards. These interesting results will be more clearly perceived in the following Table:

| Class of Persons. | Under 20. | Of 26, and under 45. | Of 45, and upwards. |
|---|---|---|---|
| Males, Free, - | 354 | 100 | 65 |
| Males, Slaves, - | 334 | 100 | 47 |
| Females, Free, - | 362 | 100 | 63 |
| Females, Slaves, | 345 | 100 | 46 |

These numerical results clearly prove the baneful effects of hard labour and coercion on the unfortunate slaves; and is most manifest in the class of 45 and upwards, the representative numbers for the male and female slaves being so very much below the corresponding numbers for the free population. If we admit, however, for a moment, that the relation

of the representative numbers of the male and female slaves, to the corresponding numbers of the free white population, be such as the laws of nature allow; and that slavery exerts no improper influence on the condition of man, then ought the representative numbers belonging to the classes under 26, and of 45 and upwards, in the free persons and slaves, to bear some analogy to each other. This, unfortunately for the interests of humanity, is not the case; for if we take the males of the classes here alluded to, we shall find, that if the slaves of 45 and upwards bore the same relation to the free males of that age, as the slaves under 26 do to the free males of the same class; then, instead of there being only 47 for the representative number of the oldest class of slaves, there should have been 61; and if a similar comparison be made for the females, we shall find, that, instead of the representative number for the oldest class being 45, it should have been 60. Hence it appears there is a deficiency of no less than 14 persons of each sex, in relation to the assumed number for the class of 26 and under 45, *occasioned, it may be fairly said, by the hard labour, and the many miseries necessarily attendant on slavery.* This is a point of view, however, much too favourable, for, considering the subject, no other reason can be assigned, why the representative numbers for the slaves under 26 are also *below* the corresponding numbers for the free persons, but that the effects of slavery have made them so. There cannot be so essential a difference in the natural constitutions of the slaves and free persons, as to create so decided a change among the representative numbers as the Table presents. The diversities must be the result of the circumstances of each.

It is most remarkable, however, that a kind of analogy should run through the several representative numbers of the same class. For example, if we take the class under 26, we shall find the female slaves nearly a fourth proportional to the free males, the male slaves, and the free females; for 354 : 334 : : 362 : 342, agreeing within three persons of the representative number for the female slaves. The same principle will also be found to agree still more closely with the last class; for 65 : 47 : : 63 : 46 nearly. Now, the proportionality of these numbers proves, that whatever may be the nature of the causes which operate on the slave population, their influence on both the sexes must be very nearly the same. But are those causes favourable to the happiness and well-being of the slaves? Are they such as to leave them no room to regret their condition, when they contrast

it with the situation of the free population which surrounds them? These are questions most interesting to the philanthropist, and to the satisfactory solution of which, every friend of humanity is desirous of lending his aid, however feeble and weak it may be. It would indeed communicate a pleasure of no ordinary kind, if it could be satisfactorily proved, that the causes so operating are not such as are hostile to human happiness, to the well-being and moral improvement of this unfortunate people. But the reverse is much to be feared.

The male slaves under 14 years of age, in each individual State and territory, exceed the females of the same age in number; and if we take the average of the whole slave population, the relation will be found to be about that of 106 to 100. But for the other classes, the preponderance will be found, in some of the States, on the side of the males, and in others on that of the females. Taking, however, the aggregate amount of each class, for all the States, the males will be found to exceed the females for all ages; though in the class from 14 to 26 they approach exceedingly near to an equality. The results of these comparisons may be arranged in a Table, and which will at once exhibit the relation between the males and females of each class:

| Ages. | Proportional number of Males. | Proportional number of Females. |
|---|---|---|
| Under fourteen, - - | 106 | 100 |
| Fourteen, and under twenty-six, | 100 | 100 |
| Twenty-six, and under forty-five, | 107 | 100 |
| Forty-five and upwards, - | 110 | 100 |

It therefore appears, that, in the transition from the first class to the second, of the slave population, the ratio of majority which at first existed, becomes gradually converted into one of equality; but that, from this latter class to the final one, the ratio again augments, and attains its maximum during the decline and close of life.

The results which the above Table affords, are so very different from those which have been obtained from the returns of the free coloured persons, that no apology may be necessary for somewhat interrupting the order of the essay, by introducing them in this place:

| Ages. | Proportional number of Males. | Proportional number of Females. |
|---|---|---|
| Under fourteen, - - | 104 | 100 |
| Fourteen, and under twenty-six, | 84 | 100 |
| Twenty-six, and under forty-five, | 86 | 100 |
| Forty-five and upwards, - | 93 | 100 |

How opposite must have been the causes which contributed to produce the first numerical columns of the preceding Tables! They are most unquestionably of a highly interesting nature, and deserving, in a particular degree, the attention of the philosopher. One principle may be clearly deduced from them, that the condition of the female is much improved by the blessings of freedom; but how far the representative numbers for the males may be safely compared with each other, considering the probability there is, that this class of the slave population is continually receiving augmentations of an irregular kind, through the various channels which unfortunately exist for the supply of slaves, is a subject worthy of much consideration. From whatever causes, however, the differences among the representative numbers may arise, their remarkable disparity renders it a question of peculiar interest, and worthy of a distinct examination.

For the purpose of estimating the rates according to which the slaves have either increased or decreased, in the several States and territories, the following Table has been computed from the respective population returns:

| States & Territories. | | Rates of Increase or Decrease from 1790 to 1800. | Rates of Increase or Decrease from 1800 to 1810. | Rates of Increase or Decrease from 1810 to 1820. |
|---|---|---|---|---|
| North. States. | Maine, | | | |
| | New Hampshire, | — 94.9 | | |
| | Massachusetts, | | | |
| | Rhode Island, | — 60.0 | — 71.6 | — 58.3 |
| | Connecticut, | — 65.6 | — 67.4 | — 68.7 |
| | Vermont, | | | |
| Middle States. | New-York, | — 3.4 | — 37.3 | — 32.8 |
| | New Jersey, | + 8.7 | — 14.5 | — 30.4 |
| | Pennsylvania, | — 54.3 | — 114.6 | — 73.5 |
| | Delaware, | — 44.4 | — 47.3 | + 7.9 |
| | Ohio, | | | |
| | Indiana, | | | — 19.8 |
| Southern States. | Maryland, | + 5.4 | + 2.7 | — 3.8 |
| | Virginia, | + 18.2 | + 13.5 | + 8.3 |
| | North Carolina, | + 32.5 | + 26.7 | + 21.5 |
| | South Carolina, | + 36.5 | + 34.4 | + 28.2 |
| | Georgia, | + 138.2 | + 76.2 | + 42.2 |
| | Louisiana, | | | + 2193.7 |
| | Tennessee, | | + 227.8 | + 79.9 |
| | Kentucky, | + 224.6 | + 99.7 | + 57.3 |
| Territories. | Alabama, | | | + 20.8 |
| | Mississippi, | | + 389.8 | + 92.0 |
| | Illinois, | | | + 445.8 |
| | Missouri. | | | |
| | Michigan, | | | |
| | Arkansas, | | | |
| | Columbia, | | + 360.3 | + 18.2 |
| The entire Slave population, | | + 28.2 | + 33.2 | + 29.1 |

With reference to the above Table, it may be observed, that, in the districts of Maine and Massachusetts, no slaves have been recorded in any of the returns; and it may hence be presumed that these districts have been always free from this class of persons. In the census of 1820, the following States, in addition to those last mentioned, were found without slaves, viz. New Hampshire, Vermont, Ohio, and the territory of Michigan; their numbers having rapidly decreased from one census to the other, so as in the last enumeration to have disappeared altogether. In New Hampshire, for example, the decrement from 1790 to 1800 was 94.9 per cent; and this diminution having been probably continued with still greater rapidity, during the succeeding periods, the

whole slave population had vanished before the enumeration of 1810; nor were any traces of their existence to be found in 1820. In Rhode Island, the decrements will be perceived to be rapid and continuous, during the whole period embraced by the Table; and, in the last census, the slaves were found to amount only to 45 in number, and these will most probably disappear before the next census of the people.

In Connecticut, the decrements have been increasing through each period, leaving, in 1820, only 97 slaves. In Vermont, in the year 1790, only 16 slaves were to be found, but not one in the succeeding census. In the State of New-York, the slaves, in 1790, amounted to above 21,000. In the succeeding ten years they received a feeble decrement of 3.4 per cent; but, in the following period, it amounted to 37.3 per cent; and in the decade from 1810 to 1820, the rate of decrease was continued at the rate of 32.8 per cent; leaving, at the end of the period last mentioned, only 10,088 slaves; so that the time may not be far distant, when the inhabitants of this large and populous province will have to boast that every native of its soil is free.

In the first of the periods included in this Table, New Jersey received an increment of 8.7 per cent to its slaves; but, in the succeeding period, a decrement of a greater magnitude was found; and, during the last period, this decrease became still greater, amounting to 30.4 per cent, leaving only 7557 slaves at the last census. In Pennsylvania, the slaves have declined very considerably since 1790, having diminished, in the first interval, 54.3 per cent; in the second, 114.6 per cent; and, in the third, 73.5 per cent; so that the slaves which, in 1790, amounted to nearly 4000, were reduced, in 1820, to a little more than 200. Delaware, on the contrary, which had received considerable decrements in the first and second periods, in the last received a small increment; its slave population, according to the last census, exceeding 4500. Maryland also, which, during the first and second periods, had received increments respectively proportional to 5.4 and 2.7, in the last period experienced a decrement of 3.8 per cent. But any increment, however small it may be, when operating on a considerable slave population, like that contained in Maryland, must be viewed with concern. In 1790 the slaves amounted to above 103,000, and these, by the increments they received in the succeeding decades, were increased, in 1810, to more than 111,000; but the decrements experienced in the last period

reduced them to about 107,000. In Virginia, also, with slaves amounting, in 1790, to nearly 293,000, we cannot but contemplate with pain so large an increment as 18.2 per cent, in the first period, 13.5 per cent, in the second, and 8.3 in the third; and though these increments form a descending series, still operating, as they do, on so large a population, the effects must be very considerable; and hence we find, that, in 1820, the slaves amounted to above 425,000, making an increase, in thirty years, of 132,000. Should these increments, during succeeding years, still diminish, we may hope to see the slave population of Virginia reduced to a stationary state; or, what would be still more pleasing to contemplate prospectively, such a series of decrements, as would speedily lead to a total removal of this unfortunate order of men. The two Carolinas also have received increments during each period, but of a decreasing kind. In the northern province of this name, the increments were respectively as 32.5, 26.7, and 21.5, during the three periods indicated in the table; and, in South Carolina, as 36.5, 34.4, and 28.2; these increments, augmenting the slave population of the former province, in thirty years, from 100,000 to 169,000 nearly; and, in the latter, from 107,000 to 250,000 nearly. Georgia, in 1790, had a slave population of above 29,000; during the succeeding ten years it received an increment of 138.2 per cent; and, in the period from 1800 to 1810, another increment of 76.2 per cent; and, in the last decade, a still farther increase of 42.2 per cent. The consequence of these rapid increments has been, to increase the slave population from a little more than 29,000, to nearly 150,000, during the space of thirty years. But the most considerable increment in the whole of the States and territories, is that which the province of Louisiana received in the period from 1810 to 1820, amounting to 2193.7 per cent. This immense rate of increase in the slave population, very much exceeds the increment of the whole population, and proves that the slaves have increased in a much more rapid ratio than the other branches of the population. This has arisen most probably from the circumstance, that the free settlers, who may have migrated to this territory, carried with them numerous slaves. The number of slaves, in 1810, amounted only to 3011; whereas, in 1820, they had increased to 69,064. During the same interval, the free branches of the population increased from 17,834 to 56,715. In the year 1810, the slaves were to the free population as 23 to 138: but in 1820, they were as 23 to 28;—a change

most melancholy for the friends of humanity to contemplate, and most striking, when contrasted with the results obtained from other territories. From Indiana, for example, where in 1810 there were 103 free persons for every slave, and in the last census no less than 773; the slaves having *decreased* 19.8 per cent, and the free branches of the population *increased* 505 per cent. The state of Tennessee, also, received a large increment to its slave population, amounting to 227.8 per cent, in the decade from 1800 to 1810; and, in the succeeding period, another increment of 79.9;—the two increments having increased the slaves from 13,584, their number in 1800, to 80,107, their amount in 1820. In Kentucky, in the year 1790, the slaves amounted to 12,430; but an increment of 224.6 per cent received during the first decade; another increment of 99.7 per cent during the second; and of 57.3 in the third period, augmented the slaves, from the number before mentioned, to 126,732, their amount in 1820. Only two enumerations of Alabama have taken place, viz. in 1810 and 1820; and, from a comparison of these, it appears, that the slaves increased during the ten years at the rate of 20.8 per cent. At the last enumeration they amounted to nearly 42,000. In the period from 1800 to 1810, the territory of Mississippi received an increment of 389.8 per cent; and this was succeeded by another of 92 per cent; the two increments having augmented the slaves from 3,489 to 32,814, their amount in 1820. In Illinois, the increment during the period from 1810 to 1820 amounted to 445.8 per cent; but this large rate of increase fortunately operated only on a small population. The slaves, however, increased more rapidly than the free persons; for, in 1810, the slaves were to the free persons as 1 to 72; but, in 1820, as 1 to 59. In 1820 the slaves in the territory of Missouri amounted to 9,722; but as this was the first enumeration, no rate of increase can be assigned. The same remark applies also to Arkansas, the slaves in that territory amounting, in 1820, to 1617 persons. In Columbia, the increment from 1800 to 1810 was great, amounting to 360.3 per cent; but which was most strikingly reduced in the next decade to 18.2 per cent. In 1820 the slaves amounted to 6,377.

On reviewing the changes which the numerical results of the slave population have undergone, during the periods embraced by the foregoing Table, some of them are perceived to be distinguished by increments, and others by decrements; and it therefore may not be uninteresting to inquire

in what way these opposite results are connected with the four great divisions into which the American States have been latterly divided. The Northern States, it will be perceived, are either altogether without slaves, or the changes which their numbers have undergone, during the thirty years ending in 1820, have been all of a decreasing kind; the whole of their numerical rates falling under the class of *decrements*. The same remark will also apply to the middle States, with the single exception of a small increment to the State of New Jersey, in the first period; and of a nearly similar increment to Delaware, in the last. But in the Southern States, the changes have been all of an *increasing kind*, excepting a small decrement received by Maryland in the last decade; and hence, with this single exception, all the numerical results fall under the class of *increments*. And it is to be regretted that these increments should have operated on by far the largest portion of the slave population in the United States; and that, therefore, as a necessary consequence, the increase of the slaves must have been very considerable. The changes also in the slave population of the territorial governments are of the same kind as those in the Southern States.

It hence appears that the numerical changes which the slaves have undergone are of two opposite kinds; and that, therefore, the United States and territories may be properly separated into two great divisions,—*the* DECREMENTS *being confined to the Northern and Middle States, and the* INCREMENTS *to the Southern States, and territorial governments*. In 1820, the slaves in the former States amounted to 22,697, and the free white population to 5,138,303; so that *for every slave there were 226 free persons*. But in the same year, the slaves in the Southern States and territorial governments amounted to 1,508,747 persons, and the free white population to 2,955,987, *scarcely affording for every slave two free persons*. The philanthropist can scarcely contemplate a more melancholy contrast than this. It would be uncandid perhaps to say, that, in contrasting the Northern and Middle States with the southern provinces and territorial governments, that the degrees in which humanity, and the graces of Christian charity, prevail, bear any proper relation to the striking results which this comparison affords;—still, it exhibits a humiliating picture of the latter provinces, when we contemplate, that, *out of every three persons, in their vast population, one of them is a slave;* and this in a country also, which, as far as its white population is concerned, has good reason to boast of its liber-

ty, and of all the substantial blessings which arise from the utmost limits of religious and political freedom. In some of these States, indeed, as the succeeding Table will more particularly display, the slaves will be found to bear a still higher relation to the white population than that above alluded to. In Virginia, in South Carolina, in Georgia, and in Mississippi, among every twelve persons seven of them will be slaves; and yet the soil of these provinces affords an easier support to their inhabitants, than the stubborn lands of Pennsylvania. In the latter State, the ground requires deep and repeated ploughing to render it fruitful; but in the former provinces, merely "scratching" it once or twice affords tolerable crops*.

It would be interesting, also, if we possessed the requisite materials, to attempt a moral estimate of the habits and characters of the inhabitants of these two great divisions of the American States. That there is room for supposing some difference to exist, may be inferred from a remark made by Dr Rush, in the paper just quoted, viz. "that our State (Pennsylvania), is the great outport of the United States for Europeans; and that, after performing the office of a *sieve, by detaining all those people who possess the stamina of industry and virtue, it allows a passage to the rest to those States which are accommodated to their habits of indolence and vice.*" The States particularly mentioned by Dr Rush, are Virginia, North and South Carolina, and Georgia. Whether, however, the character which he attributed to them in 1786, be not too strongly marked for the present period, and whether the white inhabitants of those States may not have improved in their moral habits, in common with the age, is a question worthy of the most deliberate consideration. Still, in the most favourable point of view in which the subject can be contemplated, there is much reason to fear that the solid attributes of virtue cannot be very powerfully developed in a being, who is surrounded on all sides by slaves, and who can draw no other impression from their low and unhappy condition, but such as have a tendency to debase the mind. No associations can arise from the contemplation of a social system of this kind, if social it may be called, at all calculated to exalt the human character, to develope

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* See account of the progress of population, agriculture, manners, and government, in Pennsylvania, by Benjamin Rush, M.D., vol. iii. p. 183, of the Manchester Transactions.

the pure feelings of humanity, and unfold all the better attributes of our nature.' The time, however, may come, when the American Government will feel disposed to give a practical proof of its love of liberty, by extending the blessings of freedom to her slave population. And, in the mean time, much may be done in all the States, but particularly in the southern and territorial governments, to check, by every humane and laudable means, their farther increase ; to soften and improve the condition of those who remain ; and, by freeing their minds gradually from the degrading fetters of ignorance, as well as their bodies from the dominion of the chain and the whip, to prepare them for all the blessings of a final emancipation, and to which, as moral and intelligent beings, *they are equally entitled with themselves.*

It may not, however, be uninteresting, to pursue this branch of the subject a little farther, and to trace, in a more particular manner, the numerical relations existing between the slaves and the free population, in all the States. For this purpose, the following Table has been calculated, and which, by assuming unity as the representative number for the slaves in each State, exhibits, in its proper columns, the free persons proportional to it. It may be necessary to observe, that when the character ∞ occurs in the Table, it is intended to express, that no slaves existed in the State or the territory at the time of the enumeration ;—and that when the symbol * occurs, no enumeration was taken, either of slaves or free persons.

| States and Territories. | | One Slave to | Free Persons in 1790. | Free Persons in 1800. | Free Persons in 1810. | Free Persons in 1820. |
|---|---|---|---|---|---|---|
| North. States. | Maine, | | ∞ | ∞ | ∞ | ∞ |
| | New Hampshire, | | 897 | 22981 | ∞ | ∞ |
| | Massachusetts, | | ∞ | ∞ | ∞ | ∞ |
| | Rhode Island, | | 72 | 181 | 711 | 1851 |
| | Connecticut, | | 85 | 263 | 844 | 2836 |
| | Vermont, | | 5345 | ∞ | ∞ | ∞ |
| Middle States. | New York, | | 15 | 27 | 63 | 135 |
| | New Jersey, | | 15 | 16 | 22 | 36 |
| | Pennsylvania, | | 115 | 352 | 1016 | 4972 |
| | Delaware, | | 6 | 9 | 16 | 15 |
| | Ohio, | | 9 | ∞ | ∞ | ∞ |
| | Indiana, | | * | 41 | 102 | 774 |
| Southern States. | Maryland, | | 2.1 | 2.3 | 2.4 | 2.8 |
| | Virginia, | | 1.6 | 1.5 | 1.5 | 1.5 |
| | North Carolina, | | 2.9 | 2.6 | 2.3 | 2.1 |
| | South Carolina, | | 1.3 | 1.4 | 1.1 | 0.9 |
| | Georgia, | | 1.8 | 1.7 | 1.4 | 1.3 |
| | Louisiana, | | * | * | 6 | 1.2 |
| | Tennessee, | | * | 7 | 5 | 4.3 |
| | Kentucky, | | 5 | 4.5 | 4 | 3.5 |
| Territories. | Alabama, | | * | * | 1.2 | 2.0 |
| | Mississippi, | | * | 1.5 | 1.4 | 1.3 |
| | Illinois, | | * | * | 72 | 59 |
| | Missouri, | | * | * | * | 5.8 |
| | Michigan, | | * | * | 197 | ∞ |
| | Arkansas, | | * | * | * | 8 |
| | Columbia, | | * | 4 | 3.4 | 4 |
| The whole Population, | | | 4.6 | 4.9 | 5.1 | 5.3 |

This Table brings into one point of view the relation which existed between the slaves and the free white persons in every State, and also with the aggregate population, at the periods indicated at the heads of the respective columns. In the Northern and Middle States, the numbers will be found to increase in all the periods, excepting in the single instance of Delaware, in the year 1820; but, in the Southern States and territories, they will be found, on the contrary, generally to decrease; confirming the remark before made, that, in the former provinces, the slaves have diminished,—but in the latter generally increased. Many facts of a very interesting nature may be drawn from this Table. It is curious, for example, to observe, how, in some of the States, the representative numbers for the free population augment, and become, in succeeding periods, denoted by ∞; proving the slaves to have vanished;—and how, in other cases, that

a close equality should exist, between the relations of the slaves to the free persons, at different periods;—that, although the former may have been augmented by increments of a very irregular kind, the free population should still maintain an uniform relation to them. The most striking example of this nature, is in the State of Virginia, where the representative numbers for the years 1800, 1810, and 1820, are each 1.5; notwithstanding both the increments of the free population and the slaves, in the different periods, were of a very unequal kind. The irregularities, therefore, in the increments of the slaves, must have been compensated by increments of a corresponding kind, in the free white population. In other instances, the results present examples of numbers, forming arithmetical progressions. Kentucky and Mississippi present perfect cases of the kind, through the entire range of their numerical results, and North Carolina very nearly so; although the increments which their free white and slave populations received, during the corresponding periods, bear no visible relations to them. These singular relations, together with the corresponding results of the whole population, are arranged in the following Table:

| Date. | Kentucky. | | | Mississippi. | | |
|---|---|---|---|---|---|---|
| | Relation of Slaves to Free Persons. | Increments to Free Persons. | Increments to Slaves. | Relation of Slaves to Free Persons. | Increments to Free Persons. | Increments to Slaves. |
| 1790 | One Slave to 5.0 | | | One Slave to * | | |
| 1800 | 4.5 | 199.9 | 224.6 | 1.5 | * | * |
| 1810 | 4.0 | 83.9 | 99.7 | 1.4 | 35.6 | 389.8 |
| 1820 | 3.5 | 33.8 | 57.3 | 1.3 | 87.0 | 92.0 |

| Date. | North Carolina. | | | Entire Population. | | |
|---|---|---|---|---|---|---|
| | Relation of Slaves to Free Persons. | Increments to Free Persons. | Increments to Slaves. | Relation of Slaves to Free Persons. | Increments to Free Persons. | Increments to Slaves. |
| 1790 | One Slave to 2.9 | | | One Slave to 4.6 | | |
| 1800 | 2.6 | 21.4 | 32.5 | 4.9 | 35.1 | 28.2 |
| 1810 | 2.3 | 16.2 | 26.7 | 5.1 | 36.1 | 33.2 |
| 1820 | 2.1 | 15.0 | 21.5 | 5.3 | 32.9 | 29.1 |

It is very pleasing to observe, with respect to the entire population, that the free persons have increased in a greater ratio than the slaves, through the whole of the period, since the first authorized census. This conclusion may be inferred from one of the last columns of the preceding Table, and as the fact is worthy of being particularly remembered, it may be more explicitly stated as follows:

| | | |
|---|---|---|
| In 1790, | the relation of the Slaves to the Free Persons, were as | 10 to 46 |
| In 1800, | | 10 to 49 |
| In 1810, | | 10 to 51 |
| In 1820, | | 10 to 53 |

Many other interesting relations might possibly be deduced from the Tables relating to the slave population; but it is time to hasten to the consideration of the facts which this survey of the American population has afforded, relative to the numbers devoted to agriculture, commerce, and manufactures*.

* In Counsellor Cooper's Letters on the Slave Trade, it is remarked, "that the proportion of deaths among slaves has been determined, from a series of observations, to be about 1 in 20." Adopting this, therefore, as the most probable datum to which we can at present refer, we may determine from it what proportion of births is necessary, in order to produce the slave population, at the different periods referred to. For this purpose, let A denote the amount of the slave population, at any given period, A′ its amount at any succeeding time, and $n$ the interval in years. Let also $\frac{1}{m}$ represent the rate of mortality, and $\frac{1}{x}$ the annual ratio of births; then, from the formula of population,

$$A' = A\left(1+\frac{m-x}{mx}\right)^n,$$

we may deduce, by the application of logarithms,

$$\log\left(1+\frac{m-x}{mx}\right)=\frac{\log A' - \log A}{n},$$

the latter number of which, being a known function, may be denoted by log O; hence, the preceding equation will become,

$$\log\left(1+\frac{m-x}{mx}\right) = \log O;$$

and, by passing from logarithms to numbers, there will arise,

$$1+\frac{m-x}{mx} = O;$$

and which, by reduction, produces

$$x = \frac{m}{m(O-1)+1},$$

a general formula for the annual ratio of births.

## On Agriculture, Commerce, and Manufactures.

The columns devoted to these occupations, in the census for 1820, enable us to make an estimate of the degrees in which they severally prevailed, in the different provinces of the United States; and, if necessary, by reducing the population to the same radix, to compare them with similar employments in other countries. Surveys of this nature, carried on at regular periods, and performed with accuracy and care, become in time the fruitful sources of much valuable information. By them the growth of agriculture may be traced, and the steps which mark its decline, either in the individual provinces of a state, or in the aggregate of a country at large, may be readily and satisfactorily measured. So, also, the dawn of trade, and its gradual enlargement;—the feeble beginnings of the arts, and their rapid progression, when quickened by the active springs of commercial enterprise and speculation,—all have an influence on population; and their proportional effects become manifest, by accurate periodical returns. In some divisions of a country, for example, agriculture may advance with rapidity, and make the

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From the actual enumerations of the slaves, we deduce the following results:

$$\text{For the period from} \left\{\begin{array}{l} 1790 \text{ to } 1800, \\ 1800 \text{ to } 1810, \\ 1810 \text{ to } 1820, \end{array}\right\} \text{the value of O is} \left\{\begin{array}{l} 1.0254 \\ 1.0291 \\ 1.0259, \end{array}\right.$$

and which values of O, being substituted in the preceding formula, and also the value of $m$ (20), there will arise the following values of $x$; viz.

$$\text{From} \left\{\begin{array}{l} 1790 \text{ to } 1800, \\ 1800 \text{ to } 1810, \\ 1810 \text{ to } 1820, \end{array}\right\} \text{the value of } x \text{ is} \left\{\begin{array}{l} 13.3 \\ 12.6 \\ 13.2, \end{array}\right\} \begin{array}{l} \text{affording for the} \\ \text{annual propor-} \\ \text{tion of births,} \end{array} \left\{\begin{array}{l} \frac{1}{13.3} \\ \frac{1}{12.6} \\ \frac{1}{13.2} \end{array}\right.$$

The average of these ratios is $\frac{1}{13}$th.

If we admit, with Mr Cooper, that the fraction $\frac{1}{20}$th, is a proper representative of the rate of mortality, we may be disposed to consider the annual proportion of births here deduced as too great; and that it affords the probability, that, in each of the periods above mentioned, *considerable importations of slaves must have taken place*. It would be possible, indeed, to

steps, by which commerce ascends, appear feeble and unimportant. In other States, commerce and manufactures may exhibit strong proofs of maturity and vigour, but the arts connected with agriculture display every symptom of languor and decay. These varied changes, with many other mutations of a smaller kind, may be satisfactorily estimated, when statistical surveys are well conducted, and all the elements necessary for undertakings of the kind are faithfully and properly introduced.

To estimate, in a satisfactory manner, the various degrees in which agriculture, commerce, and manufactures prevail, in the different provinces of the United States, the following Table has been computed, from the population returns for 1820, by making the number of persons in each of the classes here alluded to, proportional to a population of 10,000 persons; and to render the comparison convenient, the numerical results have been arranged in descending series, with the name of each State opposite to its appropriate representative number.

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introduce an element, corresponding to the average annual import of slaves, into a formula combining the elements of birth and mortality, and hence to form something like an estimate of the annual number actually imported. To accomplish this, it may, in the first place, be remarked, that, whether the births exceed the deaths, or the contrary, the *difference* of the fractions which denote them, must always be some determinate function of the actual population, and hence may be denoted by $\pm \frac{1}{\pi}$. If we also adopt $y$ for the average annual import of slaves, and $w$ as the representative of $1 \pm \frac{1}{\pi}$, the amount of the slave population, after $n$ years, will furnish the equation

$$A' = yw + yw^2 + yw^3 \ldots\ldots\ldots + yw^n$$
$$= y\left(w + w^2 + w^3 \ldots\ldots\ldots + w^n\right)$$
$$= \frac{yw\left(w^n - 1\right)}{w - 1},$$

and from which we deduce

$$y = \frac{A'(w-1)}{\left(w^n - 1\right)},$$

a general expression for the average annual import of slaves, in terms of their *present* number, and their average annual rates of *births* and *deaths*. All of these elements are such as a perfect table of statistics ought to furnish.

*Proportion of Ten Thousand Persons chiefly employed in*

| Agriculture, | | Commerce, | | Manufactures. | |
|---|---|---|---|---|---|
| Indiana, . | 4166 | Michigan, . | 441 | Rhode Island, | 733 |
| Louisiana, . | 3516 | Louisiana, . | 407 | Columbia, . | 661 |
| South Carolina, | 3295 | Massachusetts, | 254 | Massachusetts, | 639 |
| Georgia, . | 2967 | Columbia, . | 155 | Connecticut, | 637 |
| Mississippi, . | 2920 | Maine, . | 144 | New Jersey, | 574 |
| North Carolina, | 2727 | Rhode Island, | 140 | Pennsylvania, | 574 |
| Virginia, . | 2595 | Connecticut, . | 130 | Maryland, . | 458 |
| Arkansas, . | 2531 | Maryland, . | 117 | New York, | 437 |
| Tennessee, | 2415 | Missouri, . | 75 | Louisiana, . | 394 |
| Alabama, . | 2396 | Delaware, . | 73 | Delaware, . | 388 |
| Kentucky, | 2342 | Pennsylvania, | 67 | Vermont, . | 360 |
| Illinois, . | 2245 | New York, . | 66 | New Hampshire, | 356 |
| Vermont, . | 2161 | New Jersey, | 66 | Ohio, . | 326 |
| New Hampshire, | 2145 | Georgia, . | 63 | Virginia, . | 304 |
| Missouri, . | 2140 | Arkansas, . | 55 | Missouri, . | 293 |
| Maryland, | 1943 | South Carolina, | 53 | Maine, . | 256 |
| Ohio, . | 1909 | New Hampshire, | 44 | Michigan, . | 220 |
| Maine, . | 1844 | Virginia, . | 42 | Indiana, . | 219 |
| Connecticut, | 1835 | Illinois, . . | 42 | Kentucky, . | 209 |
| Delaware, | 1823 | North Carolina, | 40 | Tennessee, . | 186 |
| New York, | 1804 | Mississippi, . | 39 | North Carolina, | 185 |
| Michigan, . | 1650 | Alabama, . | 35 | Illinois, . | 182 |
| Rhode Island, | 1512 | Vermont, . | 33 | South Carolina, | 132 |
| New Jersey, | 1470 | Kentucky, . | 29 | Arkansas, . | 125 |
| Pennsylvania, | 1342 | Indiana, . | 29 | Alabama, . | 110 |
| Massachusetts, | 1213 | Ohio, . . | 25 | Georgia, . | 104 |
| Columbia, . | 258 | Tennessee, . | 21 | Mississippi, | 86 |
| The whole population, | 2146 | The whole population, | 75 | The whole population, | 363 |

At the summit of the agricultural column will be found Indiana, and at the bottom of the same Columbia; because, in the former State, agriculture abounds in a maximum degree, in proportion to its population; and in the latter, the least of the whole series. In the first line also of the commercial column will be found Michigan, and in the last Tennessee; and in the column for manufactures Rhode Island appears to enjoy their advantage the most, and Mississippi the least. The order in which the provinces are arranged, in conformity to the value of the representative numbers, although a little at variance with their geographical positions, will not only enable us to trace with ease the gradations in the influence of those arts, subservient to the existence and well-being of man, through all the different States, but likewise, if necessary, to ascertain the comparative relations and im-

portance of agriculture, commerce, and manufactures in each State; and also, in the great mass of the provinces at large. If we wish, for example, to compare the condition of agriculture in Kentucky with that of Maryland, we shall find, that they are to each other as 2342 to 1943; or that this necessary art prevails in the former State above the latter, in nearly the ratio of 23 to 19. In like manner, if it be required to compare the commerce of New York with that of New Jersey, we shall find, that because each is denoted by 66, they are in a ratio of equality; that is, that in proportion to the respective population of these States, commerce prevails in the same degree. So, also, if we feel desirous of contrasting the degrees in which agriculture, commerce, and manufactures prevail in South Carolina, we shall find they are to each other as follows, viz.

| | | | |
|---|---|---|---|
| Agriculture, | 3295 | or nearly as | 124 |
| Commerce, | 53 | | 2 |
| Manufactures, | 132 | | 5 |

We further perceive, that ten of the representative numbers of the agricultural column are greater than 2146, the number deduced from a comparison of the total agricultural population, to the whole population of the country; and also that 8 of the numbers in the commercial column, and 10 in that devoted to manufactures, respectively exceed the numbers 75 and 363, being those which exhibit the relation of the aggregate of each of these occupations, to the whole population. In like manner, we find, that the agriculture of New Hampshire, the commerce of Missouri, and the manufactures of Vermont, approach, in the nearest degree, to the numbers here alluded to. By a farther inspection of the Table, it likewise appears, that agriculture exceeds commerce in a maximum degree, in Indiana, and in a minimum degree, in the territory of Michigan; that it also exceeds manufactures in the greatest degree in Mississippi; but that in the district of Columbia, the representative number for agriculture will be found much inferior to that of manufactures.

The decided superiority of agriculture, i.. all the States, above their commerce and manufactures, gives room for many striking reflections, respecting the almost unbounded capabilities of the country;—of the influence which a plentiful supply of the means of subsistence must necessarily have,—in accelerating the population,—in improving their political

condition, and giving a high tone to their moral character; and, in conjunction with that active spirit, which will most probably stimulate their commerce and manufactures for a long succession of ages, must open to the inhabitants of the great northern division of the new world, treasures of a nobler kind than those afforded by the mines of Peru.

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Art. XXXV.—*Narrative of a Descent in the Diving-Bell, &c. &c.* By Dr Louis Theodore Frederick Colladon of Geneva, Hon. Mem. R. I. A. M. W. S. &c.* Communicated by the Author. [*Edin. Phil. Jour.*]

Amongst the numerous applications of the sciences to the purposes of the arts, one of the most remarkable, and at the same time one of the most important, is undoubtedly that which has carried to so high a degree of perfection the Diving-Bell, and by this means rendered it one of the most useful of machines, not only in the practice of submarine architecture at great depths, but in mining or exploding the rocks which obstruct the entrance of harbours, or in obtaining from the bottom of the sea any valuable goods which may have been lost near the coast.

Having heard when I was in Ireland in September 1820 of the employment of this machine, which has been in use for several years past at Howth near Dublin, and of the sensations experienced by those who descend to the bottom of the sea, I was very desirous to ascertain in person the accuracy of the facts which had been stated to me. It was not long before an excellent opportunity presented itself. Having obtained from my friend Mr Bald a letter of introduction to Mr Souter, engineer at Howth Harbour, I left Dublin for Howth on the 8th of September 1820, with a friend, intending to go down in the diving-bell. The weather was very fine; the wind, however, rather high, and the sea rough. We got into a boat at eleven o'clock in the morning, and in a few minutes came alongside a vessel to which the

* Read before the Royal Society of Edinburgh, April 30, 1821.

diving-bell is attached. The workmen were then at the bottom of the water, employed in clearing the entrance of the harbour.

The bell in which we were to descend may be thus described. It was a kind of oblong iron chest, cast in one single piece, open below, 6 feet long, 4 broad, and 5 high: it weighed four tons; it was three inches thick at bottom, and half that thickness at top. It was cast in London, and, including the necessary apparatus and the air-pump, cost about £200. The bell being a great deal heavier than the water which it displaces, descends by its own weight. The upper part is pierced with eight or ten holes, in which are fixed the same number of convex glasses, very thick, which transmit the light. The glasses or lenses are fixed in the top of the bell, by means of a copper ring, screwed up against the glass, between which and the bell a coat of putty is laid, and then screwed hard up, so as to render it air-tight. The top is pierced with another hole, about an inch in diameter, which receives a long flexible leather pipe, intended to introduce into the bell the air compressed from above by a forcing-pump. In the inside of the bell is a valve which serves to close the aperture, and prevent the air from escaping.

In the interior, were two small benches on opposite sides of the bell, with a foot-board between them. There was room enough for four persons. From the middle of the roof descended several strong chains, intended to sustain a kind of iron-basket, in which they place the stones or other matters which they wish to carry up. The bell in which we went down was suspended by the centre with strong ropes, and managed by means of a moveable crane erected on the deck of a small vessel. We got into the bell, which was sufficiently elevated above the surface for that purpose, by means of a boat placed underneath it. We had with us two workmen.

We descended so slowly, that we did not notice the motion of the bell; but as soon as the bell was immersed in water, we felt about the ears and the forehead a sense of pressure, which continued increasing during some minutes. I did not, however, experience any pain in the ears; but my companion suffered so much, that we were obliged to stop our descent for a short time. To remedy that inconvenience, the workmen instructed us, after having closed our nostrils and mouth, to endeavour to swallow, and to restrain our respiration, for some moments, in order that, by this

exertion, the internal air might act on the Eustachian tube. My companion, however, having tried it, found himself very little relieved by this remedy. After some minutes, we resumed our descent. My friend suffered considerably: he was pale, his lips were totally discoloured; his appearance was that of a man on the point of fainting; he was in involuntary low spirits, owing, perhaps, to the violence of the pain, added to that kind of apprehension which our situation unavoidably inspired. This appeared to me the more remarkable, as my case was totally the reverse. I was in a state of excitement resembling the effect of some spirituous liquor. I suffered no pain; I experienced only a strong pressure round my head, as if an iron circle had been bound about it. I spoke with the workmen, and had some difficulty in hearing them. This difficulty of hearing rose to such a height, that during three or four minutes I could not hear them speak. I could not, indeed, hear myself speak, though I spoke as loudly as possible; nor did even the great noise caused by the violence of the current against the sides of the bell reach my ears. I thus saw confirmed by experience what Dr Wollaston had foreseen by theory in his curious and interesting paper on Sounds inaudible to certain ears*.

After some moments, we arrived at the bottom of the water, where every unpleasant sensation almost entirely left us. We were then twenty-seven feet below the surface. I confess that the recollection of the great depth, joined to the idea that if the smallest stone, or other matter, should obstruct the action of the valve, the bell would be instantly filled with water, did not fail to create for a short time a kind of uneasiness. One of the workmen, however, to whom I imparted my thoughts on that subject, desired me, with a smile, to look at one of the glasses placed above us, which I observed to be so much cracked in the middle, that bubbles of air were continually escaping.

We breathed during the whole of our stay under water with much ease. We experienced now and then a great heat. Our perspiration was sometimes copious, and sometimes there suddenly came over us so thick a vapour as to prevent my seeing the workmen placed opposite me; but as by means of the signals they constantly sent us from above pure air, in so large quantities, that a great part of what was

* See this *Journal*, p. 26.

contained in the bell made its escape with great violence, this inconvenience very soon disappeared. Our pulse was not affected.

Mr Bald, who went down two days before me in one of the bells used at Howth, and to whose kindness I am indebted for the communication of his notes and observations, took with him a thermometer, and found the temperature of the air at the surface and in the inside of the bell to be 63° Fahr.; while the temperature of the water within a foot of the bottom (that is to say nineteen feet below the surface) was 56° Fahr.

The light which we had in going down and at the bottom of the sea was very strong. Mr Bald could distinguish very easily in descending a great number of fishes, and other marine animals, which fled at the approach of the diving-bell. The sun shone bright, and I could write and read very easily. We gathered some fuci, (*Fucus filum*, *Fucus saccharinus*, &c.) We took some marine animals, and obtained several pieces of rock, which suggest some interesting views, explanatory of their formation, which is perhaps owing, as in the case of coral, &c. to certain animals. That part of the bottom of the sea which did not present any rock, was composed of sand and pebbles. The current of water was very violent; the colour of the water, as seen through the glasses, seemed to us to be of a light green: in the bell, where we had about ten or twelve inches of it, it was quite colourless.

Having remained more than an hour at the bottom, and having seen the men work as easily as in the open air, they made some signals, and we ascended, fully satisfied with what we had seen, and convinced of the facility and safety of these submarine operations. Before we went down, they had lost their basket at the bottom of the water, and, in order to find it again, they were obliged, in using their signals, to have the bell moved in every direction, which gave us the advantage of becoming well acquainted with the method they employed to make themselves understood. In going up, the sensations which we experienced in the head were very different from those which we felt in descending. It seemed to us that our heads were growing larger, and that all the bones were about to separate. This disagreeable sensation, however, did not last long; we were in a short time above the surface, not only much pleased with what we had seen, but also with the idea of emerging safe from our narrow prison.

The signals made use of by the workmen are very simple: they consist in a smaller or greater number of strokes given with a hammer against the sides of the bell, according to the wishes of the workmen. These signals are easily heard on board, though no noise made above reaches the bell.

We must remark, that there is a north and south end fixed to each bell, and which is always attended to by those on board, so that they can be moved with accuracy whenever they want to work, either south, north, west or east.

The signals for the various operations are as follow:

1 Stroke, means more air, or pump strong.
2, Stand fast, which is applicable to all motions.
3, Hoist.
4, Lower.
5, More south.
6, North.
7, Front.
8, Back.
9, Lower down the bucket.
10, Hoist up the bucket loaded, and so on.

The men also send up a note of what they want upon a label, which is instantly attended to if practicable, or some intimation sent down to them that it cannot be done. This is effected by means of a cord, one end of which is in the bell, and the other upon deck.

It is by the signals above described that the bell is moved from one place to another in search of stones. This is effected by raising the bell a few feet from the bottom, and then, by the aid of the moorings of the ship, the bell sweeps along in any desired direction. As soon as a large stone is discovered, a signal is made, the horizontal movement is stopped, and the bell lowered over the stone. If the bell be a little aside, the workmen can, by standing in the bottom of the sea, and pressing with their shoulders against the bell, make it swing a foot or two in any direction, as it is suspended from an outrigger, at some height from the vessel's deck.

The men at Howth are principally occupied in clearing the entrance to the harbour. They are paid by the ton weight for what they quarry and send up, viz. 6s. 6d. *per* ton for very hard rock, that has chiefly to be blasted with gunpowder; 5s. 5d. *per* ton for easier quarried rock; and 4s. *per* ton for detached stone, gravel, and mud. At this rate, they are able to earn on an average 20s. *per* week all the year round. Their tonnage of rock averages 3½ tons *per* day, and detached stone 5½ tons for four men.

The method of blowing up rocks by aid of the diving-bell, as practised in Ireland, is as follows. For an account of this process, I am entirely indebted to Mr Bald's kindness.

Three men are employed in the bell; one holds the jumper or boring-iron, the other two strike alternately quick, smart strokes with hammers. When the hole is bored, of the requisite depth, a tin-cartridge, filled with gun-powder, about two inches diameter, and a foot in length, is inserted, and sand placed above it. To the top of the cartridge a tin-pipe is soldered, having a brass-screw at the upper end. The diving-bell is then raised up slowly, and additional tin-pipes with brass-screws are attached, till the pipes are about two feet above the surface of the water.

In the old practice, the tube was filled with powder as a train, and fired; but, in many instances, the heat melted the solder of the pipe, and the water entering extinguished the fire. The improved method is to leave the tube empty. The man who is to fire the charge is placed in a boat, close to the tube, and to the top of the tube a piece of cord is attached, which he holds in his left hand. Having in the boat a choffer with small bits of iron red-hot in it, he, with a pair of nippers, takes one of the bits of red-hot iron, and drops it down the tube, which instantly ignites the powder, and blows up the rock. A small part of the tube is destroyed next the cartridge; but the greater part, which is held by the cord, is reserved for future service. The workmen in the boat experience no shock by the explosion; the only effect is a violent eruptive ebullition of the water, arising from the explosion; but those who stand on the shore, and upon any part of the rocks connected with those which are blowing up, feel a very strong concussion, similar to the shock of an earthquake. A certain depth of water is necessary for safety. Mr Bald supposes at least twelve feet.

The workmen cannot go down and work when the sea is very rough, as the swell would prevent them from settling on the bottom; and they are frequently annoyed with what is termed a *ground-swell*, when it is quite still at top. This a sure prelude of a breeze of eastern wind, which seldom fails to set in soon after, if it has not prevailed at the time on the other side of the channel.

The best and easiest time for going down is at low water, when there is less pressure; but amateurs prefer going down at high-water, that they may have it to say that they were twenty or thirty feet below water in a diving-bell.

The workmen are generally down in the diving-bell five hours in the day, without coming up; and in summer, one set of men are down ten hours one day, and five hours the other, and so on alternately. They work at all seasons of the year, and do not feel much difference in the temperature. The water is more chilly in the winter; and when they come up into the atmospheric air, they feel it rather cold, after being heated by their exertions below. They do not complain in general of pains in the head, except those that are new hands, who are rather affected in that way, and about the ears; but this affection soon wears off.

They are in general rather relaxed in their bowels, which I suppose, is owing to their feet being constantly wet and cold. One of the men was very much affected with a bowel complaint this season, which increased as often as he went down. When Mr Souter descends, he is generally afflicted with a looseness: he has a copious flow of urine, and his appetite is very much increased. He always finds it a good plan to take a little spirits on coming up. The time never seems long to him when below; and he has been several times seven hours under water, without ascending, and scarcely thought it half that time.

None of the men become deaf, and it may be thought that in some cases it would be a cure for that malady.

They once had a man, as Mr Souter informed me, that was rather affected in his breathing, but when he commenced *belling*, it completely cured him.

The bellmen are in general very stout and healthy: their hard labour requires very good sustenance of three substantial meals in the day. Tea, bread, butter, eggs, bacon, potatoes, and fish, are their common diet. They are not particularly addicted to spirituous liquors. A little is very necessary for them, and it would require a good deal to affect them much.

I cannot conclude this paper, without repeating my best thanks to Mr Bald and Mr Souter, to whose kindness and liberality I am indebted for the greater part of the details introduced into this paper.

**Art. XXXVI.**—*Observations on some Animals of America allied to the Genus Antilope.* By Charles Hamilton Smith, Esq. A. L. S. [*Trans. Linnean Society of London.*]

## ANTILOPE FURCIFUR.

Prong-horned Antelope.—*Travels of Lewis and Clarke.*
Le Cabrit or Cabree of the *Canadian Voyageurs?*

A specimen of this species is in the museum of Mr Peale at Philadelphia; it is the only one preserved of those which Messrs Lewis and Clarke sent to the President of the United States during their exploratory travels up the Missouri. It is a complete skin of an adult male, stuffed with great skill, although in a very indifferent state of preservation. The following are its dimensions:

| | FT. | IN. |
|---|---|---|
| Total length from nose to tail, . . . . . | 5 | 8 |
| Height from the top of the shoulders to the soles of the fore-feet, . . . . . . . | 3 | 1 |
| Length of the head, . . . . . . . | 1 | 0 |
| From the base to the top of the horns in a straight line, . . . . . . . . . . | 0 | 9 |
| Ditto ditto along the curve, . . . . | 0 | 11 |
| Distance from tip to tip, . . . . . . | 0 | $10\frac{1}{2}$ |
| Circumference of the body behind the fore-legs, | 3 | 4 |
| Length of the tail, . . . . . . . . | 0 | $1\frac{1}{2}$ |

In the general aspect this animal resembles the chamois, though considerably larger in all its dimensions: the nose is small and the nostrils are formed like those of a sheep; the forehead broad, with the edges of the orbits of the eyes strong and prominent; above and somewhat within the posterior part of the orbits are placed the horns, which in form and character differ from every known animal of the ruminating order; they are about five inches in circumference at the base, laterally compressed, nearly flat on the inside and roundish on the outside, obscurely wrinkled and striated, and marked, principally on the inside, with small horny pearls resembling those on the horns of the stag. From the base they carry the same thickness upwards about seven inches, where the anterior part terminates in a compressed and striated snag, pointing forwards and upwards, and forming a fork with the posterior part, which becomes suddenly

round and taper, and curves backwards and inwards, ending in an obtuse point; their position on the head is nearly two inches asunder, hanging slightly forwards and outwards over the eyes; the colour brown black; the horny substance is thin at the base and a little translucent, and the hollow within sufficient to fit the two fore-fingers of a man's hand. The teeth, as far as they were visible, appeared similar to those of other Antelopes of equal size. No lachrymary sinus was distinguishable, nor could I detect the existence of similar cavities behind the horns, as are observed in the chamois. The ears are about six inches long, narrow, pointed, fawn-coloured, and lined inside with long white hairs. The forehead, nose, temples, neck, back, and hams, are of a foxy dun-colour, with the sides paler; the lips, chin, throat, a spot below the ears, one under the throat, breast, and belly yellowish white: the croup, and the long hairs which form a tuft on the stump of the tail, clear white. All the legs are bright ochre colour, slender yet firm. The pasterns remarkably long and the hoofs small, pointed, and black, measuring scarcely half an inch from the crown to the sole; there are no tufts on the knees. The texture of the hair is soft and straight, falling off readily: from between the shoulders, it points forward, on the ridge of the neck, and from the horns, where it is longer, it turns backwards, meeting at the occiput, where it forms a kind of tuft. The eye, according to a memorandum, is hazel-colour, and the whole animal presents a character uniting vigour with considerable beauty.

Having had an opportunity of showing a drawing of this specimen to a very intelligent Indian of the Kluche nation*, inhabiting the western branches of the Stony Mountains, he recognised the figure immediately, and stated its name to be *Kistu-he*, or, as he translated it, Little Elk. He observed that during winter, when enormous heaps of snow cover the mountains, these animals come down into the plains, and that they are at that time covered with long whitish hairs.

The species is found over a vast extent of country in Central North America, ranging in small herds or rather families, along the middle regions of the Stony Mountains, where

* This man had come from Nootka-Sound, and had been for some years a servant to an English fur merchant: he spoke English, and bore a singular resemblance to a Chinese Tartar.

they seem to fill the station which the Chamois does in the Alps; mixing occasionally with the American *Argali* which occupies the summits. They spread to the eastward along the banks of the Upper Missouri, and are remarkable for prodigious fleetness: to this capacity Messrs Lewis and Clarke bear ample testimony; yet the Indians hunt them with success. In the memoranda of a journal written by Mr Charles Le Rey, a Canadian trader, who passed several years of captivity among the Siour (Sioux) Indians, it is stated that, being with the hunters on the river Jaune in pursuit of these animals, the party selected for the sport a hill the ascent of which was gradual, but the opposite side precipitous: at the bottom of the slope they formed a chain of hunters, and crawled gradually and simultaneously towards the summit, inducing the game to approach the precipice. When arrived at a convenient height, they all suddenly rose and gave a loud yell, which terrified the timid creatures so completely, that most of them sprang over the brink and were dashed to death in their fall: upwards of sixty Cabrits and big horned sheep were thus slain in a single beat.

## ANTILOPE PALMATA.

Mazame? *Hernandes.*

I have adopted the trivial appellation of Palmated Antelope merely to distinguish an animal the horns of which are preserved in the museum of Surgeon's College, Lincoln's Inn Fields. All I could learn of their history is, that they were presented to Mr Hunter without a memorandum; consequently without giving any idea of the animal, or of the country from which they were brought. By some persons they were considered as a monstrous production; in their appearance, however, they bear so great a resemblance to the horns of the animal before described, that they are either of a species immediately allied to it, or possibly only a variety.

Part of their base is wanting; what remains is about eleven inches and a half long, measured upon the curve. At their present base they are two inches and a half in their greatest diameter, by one across. The anterior and posterior parts are compressed into a sharp edge, exhibiting the appearance of a hard, black, and brittle horny scabbard, with the surface strongly pearled and striated for about seven

inches towards the summit: here the anterior part of each horn terminates in a compressed leaf-like, obtuse, deflected, striated, and pearled point; the posterior part assuming a round, taper, and regularly uncinated form, much larger and more pointed than the preceding. Upon or near the ridge which unites the leaf-like part to the after-horn, are one or two small knobs or button-like horny pearls, somewhat resembling the buds of incipient ramification.

In the museum, these horns are placed together upon a bit of wood; but I apprehend their relative situation to be transposed; that is, that the right horn is fixed on the left side. This I judge from the analogy they bear to those of the prong-horned antelope; and because if the hooks bent outwards, they would arrest the progress of the animal. The reasons which induce an opinion that these horns belong not to a variety, but to a species distinct from the Prong-horned Antelope, are, that the section of the base of the Palmated Antelope's horn is lozenge shaped; whereas that of the Prong-horned Antelope is a compressed oval: that the former is on both sides striated and pearled to the bottom, or at least as far as the present base; while the latter is only striated on the surface next the forehead, and wrinkled on the outer side;—that these are not sexual differences, is evident from the horns of the Palmated Antelope being more bulky than the others, which belong to an adult male. Hence it may be concluded that they belong to a new and as yet undescribed species, the habitat of which will probably be found to be in some mountainous part of America. It is perhaps proper to observe that the *Cervus pygargus* of Pallas, as figured in Schreber's plates, bears a strong resemblance in many particulars to the first described species. I am ignorant whether Professor Pallas had opportunities to examine this species of deer with his usual accuracy.

It appears that the early writers who noticed the natural history of the new hemisphere were acquainted with one, and probably the Palmated species of these animals. I had an opportunity of comparing the figure of the Mazame in Hernandes with the stuffed specimen at Philadelphia; and though the engraving is clumsily executed, there can be no doubt that it was done from one of these animals, and the description distinctly points out the most prominent characters. "Mazames," it is observed, "caprarum mediocrium, paulove majori, constant magnitudine; pilo teguntur cano et qui facile avellatur, fulvoque; sed lateribus et ventre candentibus—Cornua gestant juxta exortum lata, ac in paucos par-

vosque teretes ac præacutos ramos divisa et sub eis oculos". Recchus justly viewed this and another species which I shall presently notice, as Antelopes, or, in the language of his time, as Capreæ. He says, " Hos (Telethcalmaçame et Temamaçame) ego potius computaverim in capreas quam inter cervos*.

## ANTILOPE MAZAMA.

Antelope of Honduras? *Anderson's History of Honduras.*
Mazame seu Cervus cornutus. *Seba, tab.* xlii. *fig.* 3.

Count de Buffon, in his article *Des Mazames*†, assumes that there were neither musks, antelopes, nor goats, nor any analogous animals in America at the time of the discovery of that continent. This opinion, for which he certainly could not have sufficient grounds, led him into the error of ascribing the animals mentioned by Recchi in Hernandes, to the deer or roe-buck kind. Indeed, the singular form of the horns in one species, rudely figured in the work, sufficiently justified a doubt, if he had not persisted in describing the other and the two figures in Seba, as deer or as African animals, notwithstanding that the last mentioned author, who obtained many of his specimens from Dutch Guiana, positively asserted that they were both from New Spain. The existence, however, of one, if not of both the species, in the warmer parts of America, is established in my own mind from the following circumstance.

Some years ago, while I was on the coast of the Gulf of Mexico, under circumstances peculiarly unfavourable to research in natural history, the canoe in which I was, having anchored within the river St Juan, the Musquito Indians

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* Nard. Ant. Recchus apud Hernandesium, lib. ix. cap. xiv. p. 324 & 325, figuras ad ipsas paginas.

† The word *Masame* or Maçame is derived from the Mexican Maçatl, which I apprehend Baron Humboldt has affixed without sufficient reflection to the Virginian stag. As far as my own inquiries have gone, the word is generic for the deer, antelopes, and musks of America. Tetlelcal Maçame, Temma Maçame, Maçatl Chichiltic, Yziac Maçame, Tlamacaz que Macatl, Quauht Maçame, and Tlahuica Maçame, all denote different animals, some of which are certainly not deer. I shall, perhaps, resume this subject, if opportunities should offer, to notice several species of deer of America, some of which are new and the others imperfectly known.

who were with me brought an animal on board, inferior in bulk to a domestic goat, but higher on the legs; in aspect resembling a small lean sheep, with soft hair instead of wool: the horns about six inches long, obscurely annulated, dark coloured, bent back, and pointed: general colour pale-rufous brown: belly, inside of legs, breast, and chin yellowish white: grey about the eyes and nostrils: tail thick and short: legs more stout than those of African antelopes: hoofs black, and the whole animal somewhat heavy in make. I was then unacquainted with the figure in Seba, and it appeared an undescribed species. Having, however, no materials for making memoranda, I was obliged to defer it: and my hungry companions soon disposed of it. I wrote to the late Dr Brown upon the subject, and he consulted Dr Dancer of Jamaica, who pointed out the figure in Seba; but as there was no copy of this work within my reach, I was obliged to defer my inquiries until my return to Europe. The figure in Seba is incorrect in expression; but when compared with his description to my own memorandum, the identity appears to me fully established. He observes, "Mazame, seu Cervus cornutus. Hæc species omnino differt ab illa quam Guinea profert. Capite et collo, crassis curtisque est, et bina gerit tornata quasi cornicula, in acutum, recurvumque apicem convergentia, retrorsum reclinata. Auriculæ grandes, flaccidæ; at oculi venusti. Cauda crassa, obtusa. Pilus totius corporis subrufus est, paulo tamen dilutior, qui caput et ventrem tegit. Femora cum pedibus admodum habilia." Buffon, who confounds his Cariacou with the Mazames, did not observe that the Cariacou or female of the Bajeu deer of Guiana has a small moist muzzle like the rest of the deer kind; while the mazames or antelopes of the same country have the nose of a sheep; at least as far as they have come under my observation. In the history of Honduras by Mr Anderson, the antelope is noticed; but (I quote from memory) he represents it as perfectly similar to *A. Dorcas*. The specimen which I saw, appeared, however, to bear a greater resemblance to the figure of the Chinese antelope about the head, or even to *A. Saiga*, than to the *Dorcas*: but as I am not positive as to the age or sex of mine, his judgment may be more correct.

## ANTILOPE TEMAMAZAMA.

Cervus Macatl chichiltic seu Temamazame? *Seba.*
Capra Pudu. *Molina?*
Ovis Pudu. *Linn. Syst. Gmel.*
Spring-back of New Jersey?

I now come to a fourth species of American Antelope, the existence of which is more doubtful; but which, in the opinion of the natives of the United States, formerly abounded and is still occasionally found in the State of New Jersey, where it is known by the name of the Spring-back. This denomination is a corruption from the Dutch spring-bock; and these people being the first settlers in that colony makes the term bock (male of the goat) the more remarkable, because their forests abounded with the American roebuck and Virginian deer: they must therefore have been acquainted with the appearance of cervine horns in all their varieties of age and species; consequently, the animal so named must have borne a character which justified in some measure the term applied. This character, it is asserted, is that of the antelope, though it is possible that it refers in reality to a species of deer whose horns are always single shoots. In the museum of Philadelphia there is a part of a skull with the horns attached to it brought out of the Jerseys, and said to be those of the spring-back: they are, however, decidedly cervine, and the production of a young deer, or of an undescribed species. But the misapplication of a name does not destroy the probability of the existence of an analogous animal to the antelope, if not any longer in New Jersey, at least in the hills and sandy plains along the frontier of New Mexico and the province of Santa Fe.

I possess a copy of a drawing obtained from an American gentleman, who stated it to have been taken from an animal shot near the sources of the Red River. Its form is light and slender; the nose small and ovine; ears long, narrow, and rounded at the tips; the tail several inches in length, and carried erect like that of the goat. In the memorandum accompanying the drawing, the size was stated "to equal a large kid; the horns to be above five inches and a half long, black, slender, and wrinkled at the base, lying strait along the prolongation of the forehead, diverging and then bending back at a slight angle". The colour resembles that of a roebuck, but is somewhat more rufous: the mouth, a

and the hoofs of a jet black, high, broad, and with deep grooves in the soles.

If I am not mistaken, Captain Vancouver first noticed this animal at Nootka in his voyage round the world. I was assured that it was found as far to the southeast as the Lake of the Woods, near Lake Superior; from thence it inhabits the regions west of Hudson's bay to the shores of the Northern Pacific.

In the present state of our knowledge, it is probable that this and the two preceding species form a small natural family; and the two first described another: and that eventually they will all require a distinct classification from the Antelopes of the old continent;—but this question must be left to the decision of future anatomical investigation.

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ART. XXXVII.—*On the Rocky Mountain Sheep of the Americans**. By ROBERT JAMESON, Esq. Prof. Nat. Hist. Edin. &c. [*Memoirs of the Wernerian Society.*]

THE Spanish missionaries in California, so early as 1697, make particular mention of a "remarkable species of sheep" as occurring in that country; and it is again noticed by Venegas, in his History of California. Lewis and Clarke also heard of it, and obtained some skins from the Rocky Mountains. I now present to the Society, a skin of this animal, which was sent from Hudson's Bay, by Mr Auld, formerly of that country, and who obtained it from the Rocky Mountains. It appears to be the Rocky Mountain Sheep of the Americans. A simple inspection of the specimen before

* This appears to be the same animal as that described by Mr Smith in the preceding article and denominated by him *Antilope Lanigera*. It is mentioned also in an "Account of the attempts to reach the sea by Mackenzie's river"—(Mem. Wern. Soc. Vol. IV. p. 23.) as inhabiting the mountains on that river. "Its horns, smooth, short, and black, are directed backwards with a slight curvature. It is about the size of the sheep, and, in the winter, has a coat of long curled hair, said to be of a silky fineness and lustre. It springs with great agility from precipice to precipice, and possessing like the sheep a very quick eye, its capture is attended with much difficulty. It has not been taken alive".—ED. B. J.

us, proves that it cannot be a species of the genus Ovis, and the form of the horns, and shape of the body, will not allow of its being placed with the Capræ or goats; while its form, beard, and fur, remove it from the genus Antelope. We are of opinion, that it forms a species of a genus intermediate between the antelope and goat. On examining the fleece, I was particularly struck with its uncommon fineness; and it occurred to me, that an animal inhabiting the temperate regions of the Rocky Mountains, with so valuable a fleece, might be easily procured, and readily introduced into this country, and form a valuable addition to our wool-bearing animals. Strongly impressed with this view, I now beg leave to suggest to the Society, providing they agree with me in opinion as to the value of this animal, to take steps for procuring live specimens from America, in order to make the experiment of introducing it into Scotland.

The Society having taken this proposal into consideration, appointed a committee of its members to consult with the Directors of the Highland Society of Scotland, on this important proposal; and also to request Mr Thomas Laurie, who has long been distinguished for his intimate acquaintance with rural affairs, to report as to the value of the wool, &c.

The following is the report of Mr Laurie.

*Remarks for the Wernerian Society on the Skin of the Rocky Mountain Sheep.*

The skin submitted to us, is, in the minutes of the Society, denominated that of "The Rocky Mountain Sheep;" and, from the wool with which it is covered, it may certainly be considered as nearly allied to that genus of quadrupeds, though, had it wanted this woolly covering, we would probably have been inclined to consider it as more allied to the goat. The general figure of this skin is very different from that of any sheep's skin I have ever seen. The difference is perhaps most remarkable in the length and figure of the neck, which, in no slight degree, resembles that of a thorough bred horse. The general structure of the head,

externally viewed, does not appear to vary from that of other sheep, more than might be ascribed to accidental circumstances. To this remark, however, the horns form a remarkable exception. Their position is very different from what is observed in the common sheep. Their curvature is also different,—circumstances which deserve more particular notice, on account of their being connected with other important diversities of character: these are the smoothness of the horns, and their circular, or rather conical shape,—two particulars in which they differ from the horns of every species of sheep with which either history or observation has made us acquainted. The blackness of the horns, compared with the whiteness of the wool, may also be mentioned, though, in other circumstances, unworthy of notice. The legs, too, of this skin, are covered with longer and coarser hair than what is to be found on those of the common sheep. The horns resemble those of a common goat, more than of a sheep, in regard to position, colour, and texture. But the goat's horns are flat on the under part, or that next the neck, so as to form the side of a pyramid. In other respects they are conical. The horns of the Rocky Mountain Sheep are completely conical, and in shape resemble the horns of an ox more than those of either a goat or any of the varieties of sheep.

There is another circumstance of apparent resemblance to the goat, which may be noticed. The skin exhibited has a ridge of hair along the back, considerably longer than the general covering, which is continued up the neck, in the form of a mane, thicker and longer than that on the back. It has also a thick long beard, and a space on each quarter covered with long shaggy hair. In these particulars, there is a resemblance to the male of the common goat; and I think it probable the skin belongs to the male sex. In the length of the neck, compared with that of the body, there is also a resemblance to the common goat. But, in all these points of resemblance, there are specific differences, which a comparison would best illustrate.

The wool forming the principal covering of the skin, is a strong reason for not classing the animal with the family of goats. It is no doubt true, that the goat of the East, yields a fur in many respects resembling wool; and it may be difficult, in some cases, to distinguish between hair and wool, especially from small specimens. But, in judging from any considerable quantity, such as the covering of a whole skin, there would be little difficulty in determining whether the

substance should be called hair or wool; and, so far as I know, there is no good authority for any species of goat ever having been found with a covering wholly or chiefly of wool.

It may be unnecessary to enlarge farther upon the classification of the animal, as the question cannot be satisfactorily decided without the possession of a living specimen.

The skin seems to be that of a full grown animal. A number of observations might be offered in illustration of this opinion. But it may suffice to state, that the horns and general aspect of the head, have all the appearances of maturity. The teeth, in particular, are evidently fully grown, and such as are observed in a sheep upwards of three years old. Four of them, on one side, are more or less broken, which may have occurred either from accident or age.

The wool, which forms the chief covering of the skin, is fully an inch and a half long, and is of the very finest quality. It is unlike the fleece of the common sheep, which contains a variety of different kinds, suitable to the fabrication of articles very dissimilar in their nature, and requires much care to distribute them in their proper order. The fleece under consideration is wholly fine. That on the fore part of the skin has all the apparent qualities of fine *wool*. On the back part, it very much resembles *cotton*. The whole fleece is much mixed with hairs; and, on those parts where the hairs are long and pendant, there is almost no wool.

The wool, if separated from the hairs, would, I think, be adapted for the finest purposes of manufacture. But, in its present state, it could not be so applied, though many of the hairs would fly off in the manufacturing processes. It is, however, highly probable, that, by a careful selection of breeding stock, the hairs might, in a great measure, or perhaps entirely disappear in the course of a very few generations. It has always been observed, that where sheep have been neglected, their wool has been comparatively coarse; and wherever they have been properly treated, and due advantage taken of the accidental finer varieties, the quality of their wool has been proportionally ameliorated. Indeed the improvement in the qualities of wool has uniformly been marked as keeping pace with the progress of arts and civilization. I am, therefore, of opinion, that the wool of the Rocky Mountain Sheep would soon become a great acquisition to the manufacturers of this country, were the animal which yields it, to experience the judicious treatment of many British flocks; and there can be no doubt,

that such an experiment would be well worth trying. Under this impression, I cannot help expressing a wish, that the Society, to whose consideration these remarks are submitted, would exert their influence for accomplishing an object which may prove of national importance.

At the same time, it is proper to observe, that sheep are not to be considered as valuable for their fleece alone. They merit attention as furnishing *food* as well as *clothing* to man, and any particular race is of value only in so far as these important objects are combined. How far the Rocky Mountain Sheep might prove useful as furnishing food, I have had no opportunities of ascertaining. As to the value of the wool, if obtained in purity, there seems no room for doubt; and I may state, that I have shewn specimens to different wool-dealers, all of whom expressed their admiration of their quality, and even an anxiety to purchase. From these specimens, however, it may be fair to add, the hairs had been in a great measure extracted.

It may be mentioned, in conclusion, that it cannot be known from the skin exhibited, whether or not the Rocky Mountain Sheep produces what dealers would call *long wool*. The longest observed on the skin is scarcely exceeding two inches, being about one-half the usual length of the full-grown fleeces of the mountain sheep of Great Britain, or what is called the carding and clothing wool, which is even much shorter than the combing sort used for worsted stuffs, &c. The comparative shortness, however, of the wool under consideration, proves nothing. Sheep cast their wool annually, if not shorn, and a new coat springs up. This generally takes place in this country about the month of June. If, therefore, the animal which produced the wool under consideration, was killed soon after casting its old wool, the new wool would not be at its full growth. This, too, is a point which could best be determined by procuring living specimens of the animal, and observing their habits and changes.

THOMAS LAURIE.

**Art. XXXVIII.**—*An account of the Eruption of Vesuvius, in October*, 1822. By G. Poulett Scrope, Esq. [*Journ. of the Roy. Institut.*]

*Naples, March* 10, 1823.

Since the end of the last century the great crater of Vesuvius has been gradually filled by the accumulation both of lava boiling up from below, and of scoriæ falling from the explosions of the different minor mouths which were formed at intervals during the last twenty years on its bottom and sides. When I visited the mountain in 1818–19, this great crater was almost entirely obliterated;—no regular concavity appeared, but in its place a rough and rocky plain, rising into two rude eminences at the northern and southern extremities, covered with blocks of lava and scoriæ, and cut up by numerous fissures, from many of which, clouds of vapour were evolved in considerable quantities. By the eruption of last October this state of things has been totally changed. The explosions which then, during the space of more than twenty days, were incessantly and with terrific violence taking place from the focus of the volcano, broke up and threw out all this accumulated mass, and ended by completely *gutting* the mountain, so as to leave an immense gulf or chasm of an irregular and somewhat elliptical shape, about three miles in circumference, if measured along the very sinuous and irregular line of its extreme margin, but somewhat less than three-quarters of a mile in its longest diameter; which is directed from N. E. to N. W. Its depth is perhaps rather above 700 feet, but decreases daily by the dilapidation of the sides.

The enormous quantity of matter, which, previously to the eruption, occupied this space, was thrown out in fragments of every size, varying from blocks of some tons in weight, to the most impalpable powder. The greater part, however, certainly issued from the mountain in the latter form, having undergone a complete trituration during the process of continued and repeated ejection. After the first four days of the eruption, the substances thrown out were solely pulverulent, becoming finer, lighter, and of a lighter colour every day. These ashes, as they are called, (certainly without much propriety, being only pulverized lava,) rose from the crater in dense and prodigious clouds, to a height, at one time, of nearly two miles, and were thence borne away on

the winds to great distances, the heavier particles falling in showers from the line of clouds thus formed along its whole track. The vast crater, which was emptied by this violent process, presents an aspect very different from that which is usually assumed by the concavities of volcanic cones. These generally appear in the regular form of an inverted cone, whose sides slope at about the same angle to the horizon as those of the outer cone. This is, indeed, invariably the case with every cone which is produced by a single volcanic eruption. That of Vesuvius, however, resulting from the accumulated products of, perhaps, many hundred eruptions, must consist of numerous beds of scoriæ and fragmentary lava, alternating with the strata of lava rock, which at intervals have been poured in fiery torrents down its outer slope, and congealing there, have remained like so many massive ribs, to give strength and solidity to the structure. Through this succession of beds, then, has the present crater been forcibly hollowed out by the explosive energy of the volcano. It appears as a tremendous abyss of enormous proportions, surrounded by craggy precipices that rise almost vertically from the rude heaps of fallen fragments which form its floor, and conceal the volcanic orifice. The extreme periphery of the crater in some parts juts over these precipices, so that on attaining its margin you look directly down into the gaping cavity. In others, a steep inclined plane, of no great width, intervenes between the edge of the cliffs and the acute ridge in which the interior and exterior slopes terminate. On this inner and shelving surface it is necessary on many points to pass while making the tour of the crater; in general, it affords a firm and safe footing, being formed of the fine sand which was the last product of the late eruption, and into which the foot sinks to some depth; but when the surface of this slope is hardened by frost into an unyielding and slippery crust, (which was the case on the morning of my first visit,) the passage is extremely perilous. The danger is, in fact, the same on the outer as the inner slope, since a slide or a false step would be probably fatal on either side; but the idea of falling into the crater is more appalling than that of rolling down the exterior of the cone.

The cliffs that encircle the great cavity by no means follow any regularity of curve, but project or recede in salient and retiring angles. Their abrupt faces which are rocky, jagged, and unpicturesque in the extreme, present sections of many currents of lava, some of which are of great thickness and extent, lying one above the other in a direction more or

less approaching to the horizontal. Most of them offer a *columnar division* of the most marked and decisive kind. Some are almost as regularly prismatic as any ranges of the older basalts. In some, the spheroidal concretionary structure on a large scale is equally conspicuous. Between the currents of lava are interposed shapeless beds of volcanic conglomerate, consisting of fragments of all sizes heaped together in chaotic confusion. These, as well as the beds of lava, are occasionally intersected by vertical or nearly vertical dikes, similar to those of Somma above the *Atrio di Cavallo.*

The whole scene presents, perhaps, an unparalleled example of the horribly sublime. The deep and yawning gulf, on the verge of which the spectator must hang to observe its terrors; the rugged and fractured cliffs that frown around it; their gloomy colouring, and calcined aspect; the dense sulphureous vapours that rise from fissures on every side; together with the thundering echoes which almost at every minute proclaim the fall of some fragments detached from the sides into the abyss below; create a sense of grandeur and awe, too impressive to be easily effaced. The great crater of Ætna, even if larger, which I much doubt, is in my opinion by no means so striking. Time and the meteoric agents have considerably softened the features of this last scene, while there is a vivid and terrible freshness in the crater of Vesuvius; the wound which has been torn through the bowels of the mountain is as yet raw and unhealed; and the imagination forcibly recurs to that powerful demonstration of the energies of Nature in all their violence, which so lately was exhibited from this spot, and which is liable to recommence at the instant.

Viewed from a distance, the crater still appears to emit at all times a considerable quantity of smoke, which increases prodigiously during stormy weather. However, on attaining the summit of the cone, it becomes evident that little or no vapour rises from the concealed vent of the volcanic focus at the bottom of the basin. Thick clouds, on the contrary, take their rise just within the margin of the crater, evolving themselves from fissures in the broken extremities of those currents of lava which were produced by the last eruption, and which without doubt are still at an extremely high temperature, probably, indeed, incandescent and liquid at their centre, since paper and wood take fire immediately on being thrust to a certain depth in their clefts. The slowness with which lava conducts caloric is well known. It is, therefore,

to be expected, that the fall of rain in any quantity would proportionately increase the activity of these vapours, which are almost solely aqueous. The moisture deposited on the surface of the recent lava currents, that nearly envelop the whole cone percolating to the interior, becomes converted into steam, and forces its way through the longitudinal rents or channels that occur in every lava current, and particularly in those whose course has been rapid, until it issues at last in clouds from the ragged edges of the stratum at the margin of the great opening.

The great cone of Vesuvius has lost considerably in height. A very large excrescence on the south side, resulting from the accumulated ejections of three or four minor mouths, and forming its most elevated point, fell in during one of the most violent convulsions of the last eruption; so that the opposite or north side of the crater is now the highest peak of the cone. By barometrical measurement I find it to be 3829 feet above the sea. The lowest part of the ridge, forming the periphery of the crater, is on the east side above Pompeia, and 3346 feet in height. The absolute elevation of the mountain has been diminished by rather more than 100 feet, while the bulk of the cone has been greatly increased by the lava torrents that clothe its sides, as well as the still greater mass of ejected fragments.

Amongst the latter products are some few pieces of granite, and of crystalline limestone with mica, vesuvian, &c. precisely similar to the erratic blocks which so frequently occur in the conglomerates of the Monte Somma; and hence it appears that the explosions of this recent eruption have shattered and blown into the air a portion of the strata belonging to that older volcano. But by far the greater number of ejected blocks, with which the slopes of the cone of Vesuvius have been strewed by the late eruption, consist of leucitic lava, and are evidently fragments forcibly torn off from those currents of an earlier date, whose sections are seen in the broken and precipitous cliffs of the crater. Many of these lavas have a highly torrefied aspect. They have obviously undergone a *recoction*, if the expression is allowable, either from having been exposed for ages to the heat, which, in the centre of the cone, from whence they were probably torn, must have been always intense, or during the period of rejection by the present eruption, having perhaps more than once been vomited forth and thrown back again into the burning gulf, before their final landing on the exterior of the cone. These fragments exhibit a more or less

pearly lustre, apparently in proportion to the greater or less degree of torrefaction they have endured. The fusion of the leucites seems to be the cause of this appearance. In some specimens this process has been carried to such extremity that a portion of the lava has run into a black glass, which fairly merits the name of *Leucitic Obsidian*. In colour, fracture, and transparency, this substance resembles the common trachytic obsidian of Lipari, but differs from it in melting before the blowpipe into a black glass, while the obsidian of Lipari is well known to produce one of a greyish-white colour.

But this is not the only alteration produced on these erratic blocks of lava, by their re-exposure to the intense action of the volcanic furnace. In some cellular specimens, the cavities are thickly lined with crystals of specular iron, and of various other minerals, hitherto undescribed, if not unknown. Amongst these, the most remarkable are delicate capillary crystals, which are found by the lens to be hexagonal prisms, hollow within, formed by the lateral junction of six long rectangular plates. They are either white, or of a light flesh-red colour, and occupy cavities which seem to have been produced by the total or partial disappearance of the larger crystals of *leucite*. Acicular radiated mesotype occurs in the same manner, as well as brilliant crystals in rhomboidal dodecahedrons, of a dark green colour. These new crystalline minerals, thus, to all appearance, created out of the elements of a lava composed simply of leucite and augite, during its re-exposure, under peculiar circumstances, to the action of volcanic heat, may be expected to throw a useful light on the origin of the numerous and problematic minerals occurring in those erratic blocks of crystalline limestone, &c. &c. of the Monte Somma, which appear to have undergone a similar process during the activity of that ancient and enormous volcano; and a stronger degree of probability is thus added to the opinion, by which these blocks of limestone, with their accompanying mica, augite, vesuvian, nepheline, &c. &c. are supposed to be, not unaltered fragments of primitive rocks, but portions, perhaps, of the calcareous or other strata which once covered the site of Vesuvius, variously affected by repeated and continued exposure to the influence of the mysterious and ever varying phenomena which take place in the fiery depths of the volcanic laboratory.

In a chemical light, the eruption of last October distinguished itself from all preceding ones by the excessive abundance

of sulphur deposited by the vapours evolved from the lava it produced. The various chemical products of these fumarole have been collected and analyzed, with great care, by Messrs Monticelli and Covelli, who have been closely occupied, since the date of the eruption, in preparing for the press a descriptive work on the subject, which will probably be out in a few weeks, and, I have no doubt, will prove extremely interesting. If I can discover any method of forwarding it to England, I will despatch it as soon as published. In the mean time, perhaps, these brief remarks may help to gratify the curiosity of the readers of this Journal.

Perhaps it is worth while to mention, that the appearance of the actual crater of Vesuvius offers a complete confirmation of the opinion I was led to adopt in France, as to the identity of the circus or upper basin of the Dordogne, in the Mont D'or, with the principal crater of that extinct volcano.

Were the fires of Vesuvius to be in turn extinguished, and its activity cease from this moment, (a circumstance by no means *impossible*,) a few centuries would probably see the interior of the crater laid open by a valley, through which the waters accumulating at its bottom, would discharge themselves into the sea; and in this event, the resemblance to the upper circus of the valley of the Dordogne, would be most strikingly exact. The lofty and precipitous rocks encircling each basin offer the same general characters; equally ragged, shattered, and calcined, they are composed alike of conglomerate beds, alternating with strata of lava, prismatic or not, and intersected occasionally by vertical dikes. From the margin of these cliffs, in either case, the outer flanks of the cone shelve downwards, with a steep and regular slope, to the base of the mountain.

Another interesting parallel may also be drawn between the large accumulations of volcanic sand (or ashes) and fragmentary lava, (commonly called lapillo,) washed down from the sides of Vesuvius by the rains, which fell with great violence during the late eruption, and those large deposits of tufaceous conglomerates, in the volcanic country of France, to which I assigned, upon the spot, a similar origin. Nothing could be more confirmatory of the justness of that hypothesis, or more clearly illustrate the mode of formation of such rocks, than the phenomena which took place on all sides of Vesuvius, a few days after the great crisis of the eruption in October last. The fine impalpable sand thrown out from the crater for many days together, had covered the surface of the mountain to the depth of from one to five feet; and

necessarily impeded whatever rain fell upon this space, from draining off, as usual, through the porous and loose matters which compose the sides of the volcano. In this state of things, on the 27th October, the clouds, which had long gathered in dense masses around and above the cone, began to discharge their contents in prodigious quantities; and, in consequence, torrents of sand, mixed with water, appearing like liquid mud, swept with terrible impetuosity down the slopes, tearing them up in their passage, hurrying along fragments and blocks of lava, of great size, (some even from 40 to 50 feet in girth,) and depositing heaps of alluvium on the sides and at the foot of the mountain. The damage occasioned by these "*lave d'acqua*," or "*di fango*," as they are called in the language of the country, was far greater than what was suffered from the "*lave di fuoco*." The latter only destroyed a few acres of wood and vineyard, but by the former a much larger space of cultivated soil was devastated, walls were overthrown, houses and streets filled with sand and stones, and some lives even lost, from the suddenness of their descent.

There can be no doubt, that a great portion of the tufa strata, under which Pompeia and Herculaneum lie buried, were deposited by alluvial torrents of this nature; and I make no question but that parallel phenomena, on a larger scale, produced those massive formations of tufas and breccias, which shew themselves in such abundance around and upon the extinct colossal volcanoes of central France.

P. S.—I open my letter to say, that accounts have just arrived from Sicily, of an earthquake having done great damage in that island. Palermo has been shaken dreadfully, about thirty lives lost, and houses injured to an extent of loss equal to half a million sterling, it is said. Messina and Catania have suffered much less. It is difficult to say whether this calamity has any connexion with the eruption of Vesuvius last year, or with the dreadfully stormy weather we have had since. It is a very unusual phenomenon at Palermo.

ART. XXXIX.—*Narrative of an Ascent to the supposed Volcano of Arequipa, or Peak of Misté in Peru.* By SAMUEL CURSON, Esq. Communicated by the Author.

IN the latitude of 16° 24′ south, and longitude 71° 42′ west is situated the valley of Arequipa, remarkable for its agriculture, the dryness of its atmosphere,* and the singularity of its situation.

Its form is oval, rather lengthened, being about twelve miles in length from east to west, and six in breadth from north to south, elevated at the lowest part about seven thousand feet above the sea. Its southern side is bounded by stony ridges between two and three thousand feet high; overtopped on the east, and thence round to the north-west, by colossal mountains, some of them thirteen thousand feet higher than its own level; and watered by a river which, after running through its whole extent, discharges itself in cataracts over rocky declivities in the west.

On the north-east side of this valley is the city of Arequipa, elevated seven thousand, seven hundred and seventy-five feet above the sea, behind which rise the three loftiest mountains called Chacheni, Misté, and Pichu Pichu. The *Volcano* or *Peak of Misté* is three leagues north-east from the great square of the city; but such is the effect produced by its great elevation that, at night-fall or by moon-light, it seems almost to overshadow it.

The ground rises gradually from the city towards this mountain, a distance of about five miles, over one of those sterile tracts known in Peru by the name of Pampas, and is then broken into ridges forming part of its base, and these are covered with verdure which increases as you ascend in that direction.

The atmosphere about the Peak of Misté is exceedingly transparent, (which may be owing partly to the porous nature of the materials of which the peak is formed, and to the consequent rapid melting of the snow, aided by the free passage of air underneath). The inhabitants of Arequipa are never surprised by the fact that many months pass without

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* The Hygrometer of Kater which, with the Levant wind, at Cadiz, only falls to 3 40-100, ranged here from 1 23-100 to 2 29-100 during a whole year.

a cloud being seen on this summit; while on the contrary they are always ready to imagine, when such a phenomenon does occur, that something extraordinary has happened in the interior of the mountain;—that earthquakes are near, or that the Peak may explode and bury their city under its eruptions.

These apprehensions have operated so strongly on the inhabitants at different periods, that they have been on the point of abandoning their city.

In 1667, an unusual alarm having been excited by an eruption from the Volcano of Omate, about forty miles distant, (after which the summit of Misté was enveloped in dense clouds) the Corregidor Ayala ordered four persons to ascend the mountain and examine into the appearances about the Peak; but these persons, neglecting the advice of the Indians best acquainted with the ascent, were unable to execute his orders. The alarm increasing, Father Alvarez Merundez, a Dominican friar, accompanied by some curates and a large number of Indians, then attempted to gain the summit. It was said they effected their object, and, "by the aid of a portable altar, celebrated mass half way up". Of the crater, so much feared, they only reported that it certainly was a crater, and had a circular elevation of sand in the middle from which smoke exhaled.

In 1784, an earthquake, which laid in ruins a large part of the city of Arequipa, renewed the terrors of the inhabitants with regard to the Peak of Misté; and no younger person being found bold enough to attempt its examination, the bishop of Arequipa, Father Miguel de Pamplona, at the advanced age of eighty, undertook the enterprize himself.

It would appear, however, that the intendant, wishing to have the merit of the discovery, as it was then called, to himself, incited Don Francisco Suero, a hotheaded Irishman, to undertake it in opposition to the bishop's wishes. Suero with his Indians passed the bishop on the way, while the latter was sleeping, and scaled the peak on the northern side, descending on the east to avoid meeting his competitor.

The aged bishop, after suffering severely from cold and other causes, attempted to follow Suero, at first on foot and afterwards in a litter; till finding himself exhausted by fatigue and bruised by the probably intentional striking of the litter against the rocks, he sent his Indians forward with an iron cross, to be planted on the south-western side of the peak facing Arequipa, and directed them to explore the

supposed crater in the south-east. It is probable that their ambition to plant the cross higher than human feet were supposed to have trodden before, excited the Indians to execute this part of the bishop's orders; but they left the crater unexamined and unreported, except by vague traditions similar to those already current.

On Suero's return, his statements, owing to his own want of observation, or to the intendant's orders, were so obscure, that it was doubted whether he had visited either the Peak or the crater; and the subject being still considered very important, a commission was named in the next year by the intendant, who placed his secretary Don Francisco Velez at the head of it, and added Suero with three other persons to assist him, besides a great number of Indians. Only one or two of the party finally reached the summit, and these gave no satisfactory account of what they had seen. They furnished, however, a pompous report for the Court at Madrid, which was perhaps what the intendant most wanted.

At length in 1796 Thaddeus Haenk, a Bohemian naturalist in the service of Spain, ascended to the summit after great sufferings; remained there some hours, and ascertained the size of the crater; but I could never learn what his opinion was respecting the state of the Volcano, and in the year 1811, when I arrived at Arequipa, public opinion seemed to be still entirely unsettled on this subject. Too many people were as willing as ever, and perhaps more so, to believe themselves in hourly danger of a fresh eruption; a cloud never rested on the mountain without exciting apprehension, and the shock of an earthquake was sure to fix all eyes on the summit of the Peak with fearful anxiety for a succession of days. The extravagant opinions and reports respecting the Peak of Misté made me desirous to examine it; and, though the project was combatted by many friends whose heads were filled with the fearful reports of the sufferings of Velez and his party; yet the intendant, as well as the bishop, encouraged me to expect success, and three other persons* among the number of my friends, were found willing to share with me all the threatened dangers and fa-

* Don Francisco Valdez de Velasco, Don Vincente Cruz de Albistur, and Don Manuel Tello; the first a Roman, the second a Biscayan, and the last a Peruvian creole. It seemed singular that four persons from such distant parts of the globe should happen to be companions in such an expedition.

tigues. I therefore finally determined on making the attempt on the 27th of October, 1811.

I prepared for the ascent by providing myself with a quadrant (the only one in Arequipa), thick clothes for cold, stout shoes, and a stock of lemons, as well as thirty or forty yards of rope to descend into the crater. My companions on their part furnished themselves with some provisions, and a large stock of squibs and rockets with which they meant to give notice to their friends in the city when they should have reached the summit.

At daylight on the morning of October 27, Valdez having first made his appearance, we called up our other companions and went to mass to prepare ourselves for "entering on our great undertaking."

At seven we left Arequipa on mules, accompanied by my trusty servant Reymundo, and took our way over the *pampa* or plain above the city, beyond which we passed a ridge of hills seven miles from the city, which separate the curacy of Chiguata from the Campina de Arequipa. I estimated the top of this ridge to be three thousand feet above the city. Descending on the eastern side of it, we came to a run of salt water, from which the village (eleven miles from the city) takes the name of Agua Salada.

A mile farther on we reached Cangallo, a small farm belonging to the friars of the order of Buena Muerte, and producing potatoes and grass. This farm being conveniently situated on the great road is not without its *tambo* or tavern, where cattle are taken care of and travellers may dine very comfortably, if they have brought their dinner along with them, and are able and willing to cook it.

The mercury in my barometer stood here at 21.430 inches, and at 68° in Fahrenheit's thermometer, which would indicate an elevation of 9,602 feet above the sea. The humidity of the atmosphere was only equal to $1\frac{48}{100}$ or $\frac{15}{100}$ less than at Arequipa*.

The soil at Cangallo is naturally bare of vegetation, though a little alfalfa or lucerne is raised by means of artificial irrigation; but the side of the mountain, visible in the north, has a distinct belt of verdure extending about one-third of the distance toward the Peak, and nourished as it

* The range of the thermometer throughout the year at Arequipa is between 52° and 78°, the greatest cold is in June, and the greatest heat in December.

would seem by the vapours which hang about the base of the mountain.

While I was employing myself at Cangallo, in sketching the appearance of the neighbouring land and arranging my barometer, I was visited by the cacique of Chiguata, Don Francisco Arenazas, who had received orders from the intendant to assist me in the ascent. He brought with him in consequence a number of Indians, of whom I selected six for guides. Two of them were to carry provisions on horseback, the first in company with us, and the other to meet us on the north side of the Peak, where we proposed to sleep, and proceed afterwards on foot. The other four Indians were to follow us on foot as well as they were able.

Having taken some refreshment, I directed my Indians to purchase provisions, and taking leave of the cacique, we passed a plain that rose gradually towards Yachi in the north-east. We found the slope on which we advanced soon covered with light herbage, which gradually increased till in the neighbourhood of Yachi we found bushes of considerable size. At the foot of the height of Yachi we passed a chasm of which many are formed by the rapid torrents in the months of January and February. We descended into it about two hundred feet. The sides were formed of alternate strata of coarse and fine soil, with some variations of colour, and intermingled with round stones very smoothly worn but not discoloured. Pieces of pumice-stone were, however, here and there visible in the strata, some of which, particularly the upper parts of them, were of earth as fine as ashes and nearly white.

The bottom of the chasm was of solid rock, worn smooth by the water. I had not time to break off a piece of it, but from a passing observation I judged it to be sienite; it had here and there a more compact appearance, resembling grey porphyry.

The humidity in this hollow was sufficient to bring forward some thrifty bushes, from among which we provided ourselves with walking sticks to serve us in the ascent. Leaving the gulley we mounted by an almost perpendicular path the height of Yachi, where we had a view of the plain of the same name, with a road leading over it to a sort of pyramid made of the bones of mules which had perished here in consequence of the diminished pressure of the atmosphere on the lungs at this elevation. The singular effect this produced is generally known in Peru by the name of "*Sorroche.*" It is seldom experienced below eleven thousand

five hundred feet elevation; at twelve thousand five hundred it is sensibly felt by beasts as well as men, and on reaching thirteen thousand and fourteen thousand, few persons can bear up against it. It affects human beings like sea-sickness, causing a swimming in the head and nausea, with extreme restlessness and head-ache. The Peruvians attribute it to antimony, with which they suppose the mountains are more or less charged! This name may probably have been derived from the Quechua or Peruvian language, perhaps from the word "Surruchec"—to faint or disappear.

By an observation made with the barometer, the temperature being 62° Fahr. the elevation of the south-west end of the plain between Misté and Pichu Pichu was found to be twelve thousand four hundred and fifty-nine feet above the sea. The hygrometer marked $1\frac{43}{100}$.

As soon as I could finish my observation, the clamours of my companions obliged me to remount and overtake them, when we rode for about a league in a north-west direction over an ascending plain of sand towards the pile of bones, from which this place takes its name (Alto de los Huessos). In crossing this plain I observed at intervals numbers of round stones scattered in every direction, which at first sight appeared to have suffered from the action of fire. On approaching near to some of them of six or eight feet dimensions, I observed that only the southern side, exposed to the trade wind, had this red appearance, the other side retaining its natural colour and being perfectly smooth and hard. These stones seemed generally to be of grey porphyry*, some that were darker rather to incline to slate.

From the pile of bones we proceeded towards the north-west, and entered a tract of high prickly grass skirting all the eastern side of the Peak, and vegetating in sand and light dust, which latter greatly incommoded us, rising with the least air, and well nigh stifling both us and our mules. All this grassy tract was full of partridges who had their nests in the fine dust under the tufts of grass and were so very tame that we rode close upon them before they rose, and even then they seldom flew out of gun-shot. The Peak viewed from the pile of bones exhibited a broader base from north to south. Large ridges covered with grass rose from the plain, one above another, till they reached a steep barrier of sand which prevented access on this side to the sum-

* Probably Trachyte. Ed. B. J.

mit, we could only here see a body of craggy rocks which we mistook for the summit above us, projecting considerably, and having very little the appearance of a volcano. We attempted once or twice to pass the ridges which crossed our route, but found them too abrupt, and only tired ourselves and our mules in the effort. Our Indian guide discovered here so much ignorance of the road that I determined to take the lead myself, and turning the foot of the north-eastern ridge, I proceeded directly westward, ascending as much as possible. We were here obliged to be very careful about hurrying our mules; for the sorroche now began to affect them as well as one or two of my companions.

We however continued to advance, climbing and plunging among these grassy hummocks, until with the last rays of light we came to a high ledge of rocks descending towards the north. Finding ourselves much fatigued, we determined to rest here, though I was anxious to reach the spot where we were to leave our mules. We selected a spot of fine black sand and while some prepared grass to lay our pillows upon, others kindled a large fire with yarete* as a signal to the Indians we expected to join us, as well as to heat our provisions and water for lemonade. My companions were busy firing rockets which they thought would be seen from Arequipa. I very much doubted this, but running up the ridge to join them I found myself almost exhausted by a sudden difficulty of breathing; and perceived how completely the inhabitant of the coast is disabled on his first arrival in these elevated regions.† After resting a while we endeavoured to take a few mouthfuls of food before we tried to sleep; but it was in vain. The sorroche had deprived us all of appetite except the guide and my servant. The same cause prevented Valdes and myself from sleeping, and we kept watch through a very fine night. Not a cloud obscured the sky, and the moon shone with unusual splendour. My thoughts were busy with all that was dear to me in distant regions, and these feelings were naturally cherished by the

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* A resinous plant growing in the form of a cup reversed—the branches close and matted, bending down so as to touch the ground conceal the stem which is not more than an inch thick when the plant is a yard in height.

† When Almagro and Pizarro were contending for the government of Peru, the former was advised by his friends to attack Pizarro's army while they were ascending the defiles of the Andes, because, being overcome by the sorroche, they would be unable to resist. The high minded Almagro rejected the proposal as degrading to a Spanish soldier, and shortly after at Salinas, near Cuzco, he paid with his life for his generosity.

romantic appearances about me. The arrival of two more of our Indians put to flight all these waking visions and left me only the unpleasant realities of increasing cold and thirst, heightened by the effects of sorroche. Towards morning I observed frequent electric explosions in the north-east; some of them so vivid as to illuminate the whole atmosphere.

It is probable they were produced by the condensation of the atmosphere of the coast when met by the cold air of the Puna* in its nightly descent westward.

On the 28th the day broke extremely cold. It was in vain I roused my party, none of whom were willing to leave their warm quarters and encounter the sharp north-east air from the Puna. Nightcaps and handkerchiefs had been insufficient to keep our heads warm, and the edges of our blankets exposed to respiration were fringed with icicles. Our mules were saddled and our fire renewed before I got the party on their legs. They all complained bitterly of the cold, and as it appeared with some reason; for our small stock of water which had been secured in the dry grass, under the head of our bed, was found hard frozen, and a bottle of wine left exposed to the air was half congealed. The moisture of the atmosphere was $1\frac{23}{100}$—the thermometer marked 26° above zero, yet my lemons when thawed by the fire immediately froze again on exposure to the air. Our Indians had slept soundly in the grass with only a light rug for a covering, and their legs and feet quite bare. At this place a barometrical observation gave 13,567 feet, a greater elevation than the Peak of Teneriffe.

I remained here till sunrise, about which time another of my Indians arrived on horseback but without water or intelligence of the bearer of it. Small as was the stock on hand I still determined to advance, hoping that our watermen would overtake us before we reached the north-west ledge. Accordingly we mounted the rocky barrier before us to proceed westward, but our further progress was arrested by a precipice that for some time baffled all our efforts to pass. If we had made the attempt on the preceding evening the result may easily be imagined, for, as it was, we had great difficulty to find an outlet free of danger. We reached however in safety a grassy slope of about a mile in extent terminated by another rocky ledge. In passing this slope we all

* A Peruvian word, signifying a plain elevated more than 11,000 feet, so as to be within the range of the sorroche.

experienced more strongly the effects of sorroche and our mules hardly kept upon their legs.

Our situation in this passage was by no means pleasant, for the slope at a short distance below was intersected by an abrupt precipice falling several thousand feet into the river Arequipa; and before we reached the ledge west of us, the saddle slipped over the tail of my mule in one of the sandy ascents, and I came down enveloped in *ponchos**, pillions and saddle-bags, at the imminent risk of my neck.

The frightened mule plunged away by herself down the slope towards the chasm, and was only saved from destruction by Reymundo's noose adroitly thrown over her neck when at full speed. This accident determined me not to advance any farther on mules, but rather to commence the ascent on foot from the next ledge, believing it must communicate at a short distance above with the great north-western ridge which it was my object to attain. At the foot of the next rock I therefore mustered my party. Valdes and his mule had both sunk under the sorroche on this sloping plain, so that I was obliged to send Reymundo back with him and with all our baggage, with orders to wait for me in the upper part of the grassy region west of the pile of bones, taking care to keep up fires after dark and to discharge rockets at short intervals. At seven o'clock Tello, Albistur and myself resolutely commenced our ascent on foot, accompanied by three Indians who carried some yarete to kindle a fire at the summit, the rope to descend into the crater, my quadrant, and a few necessary refreshments. Our elevation was then about 14,000 feet. The Peak above us presented the appearance of three horizontal strata of rock, the uppermost of which, of craggy and perpendicular aspect, we supposed to be the same rocky crest which we had seen from Arequipa. The Indians advanced faster than we did, though they also suffered from shortness of breath. For myself I suffered greatly, not only from the sorroche, but also from the effects of a sleepless night. I had frequent returns of headache, dizziness and nausea, each of which seemed to leave me weaker than the last—and I began to have strong doubts whether my strength or spirits would hold out to the

* A mantle 9 feet long and 5 wide, with an opening in the middle, through which the horseman puts his head. They are made of various materials—light cotton for dust, thick woolen for cold, and wool and hair for rain. Some of the latter are very costly.

top.* Tello gradually fell behind even me—for though accustomed to travelling in the Puna, he had against him the weight of fifty-four years spent in extreme hardships. He used great exertion, but in vain; at last he was obliged to halt every seventy or eighty paces, and, as our staying with him would have prevented our reaching the summit before night, I urged him to return before he should suffer still more from fatigue. After some time spent in convincing himself, or rather allowing himself to be convinced, that he had gone higher up than the bishop of Pamplona, he at last consented: but now it was impossible for him to overtake Reymundo and the mules, whose situation we ascertained by the dust they raised, and he was obliged to take another path to meet them. We were therefore forced to send an Indian with him, and to diminish our baggage by leaving the rope and part of our provisions. To Tello and his Indians I ceded my only bottle of brandy, and half of my water; we then took an affectionate leave and parted. At this point the last vestige of vegetation disappeared. For some distance previous the yarete had been so minute as nearly to resemble moss. The second division of the Peak which we now began to ascend, appeared to be a mass of red rock, to reach the top of which two sandy ascents were passed which exhausted even the strength of our Indians.

The effects of sorroche had increased, and the heat of the sun was troublesome also. We had too little water to allow ourselves more than a spoonful at a time to clear our mouths of the fine dust which at times threatened to suffocate us. Here too we found our lemons of great use, particularly in lessening the dizziness which had begun to annoy us greatly. It was ten o'clock when we commenced this ascent, and here I found that I gained on my companion, whose spirits failed with his strength, while mine were excited by the idea that we had finished two-thirds of our labour. The surruchee however was so strong at the summit of this ridge that we could not advance more than fifty paces at once, and were obliged to halt at each interval fifteen or twenty minutes. The height of this spot, deduced from Haenck's estimate of the greatest elevation of the Peak, would be about sixteen thousand four hundred feet.

* On another occasion, however, in crossing the Andes from Lima to Pasco I suffered still more, owing I believe, to my having eaten more than here, and to my wanting the lemons which relieve the lungs considerably in these situations.

The want of water too, added much to our suffering. Our mouths were parched still more by the dryness of the atmosphere, (Kater's hygrometer marked 0.93,) and the fine dust at times almost choked us, the arteries of our temples were swelled by the sorroche. At every resting place we seemed nearer and nearer to suffocation, and went on with a feeling of desperation, as struggling for life. Our Indians excited us to persevere by the hope that each new effort would bring us to the summit, and but for this artifice it is doubtful whether we should have succeeded at all. At length we reached a large body of red rock, at about eighteen thousand five hundred feet elevation, and here, to our great joy, gained a view of the top of the mountain with Pamplona's iron cross and the cavity on the eastern side which marks the situation of the crater. Enlivened by this view, after swallowing our last spoonful of water and eating our last lemon, we were enabled to view the scene around us with feelings something like admiration. We looked down on every thing but Chacheni, which seemed to raise its snowy head in the north-west to even greater elevation. A long strip of white clouds under us concealed the chasm between the two peaks. In the west the view was only bounded by the deserts. In the east-south-east the salt pans behind Yachi were seen over Pichu Pichu, in the east the volcano of Ubinas on the Cordillera, and the white summit of Illimani on the eastern Andes near La Paz; in the north-east the horizon was bounded by the mountains of Cuzco, between which and us lay an immense extent of desert, where the river of Arequipa, reduced to a rill, disappeared from view. Much time might well have been spent in feasting on so impressive a view, but the lateness of the hour, and the increasing cold, now at 36° of Fahrenheit, warned us to proceed. We pressed forward in a south-west direction toward the summit, till we reached the elevation of nineteen thousand two hundred feet*. The mountain of Chacheni presented here a volcanic appearance. It seemed to be formed of four peaks closing toward the summit and leaving in the middle a vast hollow, and each had the same appearance of a crater opening toward the south-east. My thermometer fell to 32°, and the wind increasing in violence from the south-west brought along with it a great body of clouds

* This is within 200 feet of the height attained by Humboldt and Bonpland, in 1802.—(*Edit.*)

which concealed the plain for many leagues from the base of the Peak.

I determined to lose no time in examining the crater. My Indians on reaching its mouth were forced by the violence of the wind to crouch down to the ground, but notwithstanding this inconvenience and the cold, now ten degrees below freezing, I surveyed the crater for some time in silent wonder and admiration. On the western side were lofty rocks of one hundred to one hundred and fifty yards in height, declining to forty and fifty in the north and apparently of very little elevation in the south and south-west. The extent of the opening from south-east to north-west I judged to be six hundred yards, and the breadth half as much. All the rocks on the north-west side were of a red colour, the points very irregular and ragged, as if torn by convulsions of the crater. On the north-east side they were tinged with white and yellow spots, as my guides informed me, by sulphur. The bottom was nearly covered with white sand laying in drifts round the edges, as if blown so by the wind. In the middle rose a circle of black sand, low and almost open in the south-west, and highest in the opposite point. The heavy gusts of wind entering on the south-west, often traversed the crater with a loud roar, and may probably have led to the belief of subterranean fires. Every time this whirlwind made its circuit it threw up columns of the fine black sand, in a form which may easily have been mistaken at the city and adjacent villages for eruptions of smoke. The error could only be detected by observing their sudden disappearance. The sand in the crater seemed entirely unmixed with stones. The cold within the sandy circle acted evidently with great power on the comparatively temperate airs that passed over it; the thin vapour which reached its verge increased suddenly in density, and settled into the middle of the circle, probably in the form of snow or sleet.

Other vapours appeared on the edge of the rocks in the south-west, and seemed to increase in length and whiteness as they advanced towards the circle. Pressed down to the rocks by the wind, they had a most strange appearance. My Indians called this phenomenon the "serpent of the volcano." My barometer sunk here to $15\frac{450}{1000}$, which would give the elevation of seventeen thousand and sixty-six feet only, but the mercury did not vibrate in the tube, and fine streams of it escaped from the index glass as well as from the joints of the cistern, indicating that the latter was com-

pletely filled by the descending column of mercury, and consequently that the instrument would give a measurement much short of the true one.

The Peak of Misté was carefully measured in 1794 or 1796 (by angles taken from the plain near the city) by Thaddeus Haenck, who found the south-western crest to be three thousand one hundred and eighty toises, or twenty thousand three hundred and twenty-eight feet, above the sea; according to which, the spot on which I stood would be nineteen thousand seven hundred feet, it being within six hundred feet of the cross on that crest.

While pausing to look around me at this great elevation, I could not avoid framing something like a plausible theory which might explain the most striking appearances that met my eye. It seemed unlikely that the sand existing in such great abundance, on the side of the Peak from north-east to south-west, in a direction opposite from the prevailing winds, as well as in the crater itself, should have been thrown out by the volcano. The loose stones on one side of the mountain are not covered by it, and if they were last thrown out, why should they not have been scattered, more or less, over the whole surface of the mountain, and of course be still to be found there? The fact is, that the vestiges of former eruptions from this crater exist only at an elevation of at least eighteen thousand feet, or buried at the foot of the mountain, while the crater and the southern declivity are loaded with sand. May we not be fairly led to presume from these facts, that the volcano was antideluvian? The rushing of the great waters from the south would have produced just such appearances as Misté and Chacheni now present. The former would be (as we find it) choked and loaded with sand—while the latter, presenting a firm barrier to the passage of the waters, would be stripped of its soil, and the ocean, forcing a passage between the two mountains to the plain of the Andes, would have left the north-west side of Misté rough and precipitous, as it now appears. While I was amusing myself by these speculations, one of my Indians came to tell me that Albistur was spitting blood, and that they all were perishing with cold. I hastened to join my companion, and was a good deal alarmed when I observed the quantity of blood he had raised, though I treated the matter lightly to avoid lowering his spirits. The accident prevented our proceeding to the cross (six hundred and twenty-eight feet higher), and we determined to make the best of our way toward the eastern side of the crater, to

begin our descent. Soon after commencing our march, we were much surprised at observing the print of human feet in the sand, apparently very recent. We presumed that the person who had ascended, unobserved by us, could not be many hours in advance, and were at a loss to imagine for what purpose or by what path he had arrived before us at this great elevation. It seemed most probable that some of our own party might have straggled in this direction, after mounting by some path still more precipitous than that which we had followed. My Indians suggested that the person, whoever he was, might have come there in search of sulphur—hinting at the same time that he might also have come in search of something else of more value.

Proceeding on our route I observed that the Indian guides followed a very crooked line of march, and inquiring into the cause, I found they were following the footsteps of the stranger who had preceded us. At last they stopped, affirming they had discovered the cause of his visit, and, pointing to a small excavation in the earth before us, assured me it was "silver and gold" that had brought him here. The day was just closing, and there was barely light enough left for me to observe the appearance of the earth to be different from any we had previously seen. Our Indians seemed to exult in their discovery of this spot, and said they had for some time suspected that the Chiguata people "could not have come so far for sulphur only". At the same time they gravely assured me it promised fair for a rich vein of silver, and I took up a few specimens in consequence, which proved to be grey porphyry with feldspar and not burnt. Leaving the Indian's track, we proceeded toward the north-east, and were agreeably surprised by the discovery of a body of ice, which greatly refreshed us, and particularly Albistur, who was almost sinking under his various fatigues. Our Indians took some large pieces along with them, and we then continued our descent along the north-east side of the crater, where I perceived a strong smell of sulphur, which yet hardly amounted to the suffocating vapours that Don Francisco Velez says he found issuing from the mouth of the volcano. The Indians it appears often ascend on this side of the mountain in search of sulphur, and many traditions are extant of greater treasures, such as the concealed relics of the Incas, and veins of the precious metals—the existence of which is certainly not impossible, and gains some appearance of probability from the superstitious secrecy of these people with regard to any traditions received from their fa-

thers, as well as from the frequency of their visits in this direction and familiarity with the mountain paths. A ridge of high rocks preventing our progress in the direction we had taken up, we turned to the eastward on the same body of burnt stones as before, winding in this way round the foot of the crater. As the day closed, the moon, now at its full, gave us a perfect view of our route, and discovered below us a very singular appearance. The great mass of clouds which had been forced up the Charcani passage, during the afternoon, and covered the descents to the north and east, now lay spread in every direction below us, and the points of Pichu Pichu and its neighbouring summits piercing through, here and there, looked like islands in a sea of fog. Even these at times disappeared, and we seemed as if alone in the world. The effect on our feelings was very forcible, and would appeal strongly without doubt to the dullest imagination.

After some anxiety about the line of our march, in consequence of looking in vain for the expected signals from Reymundo and the party below, we were greatly relieved, at nearly eight o'clock, by the sight of a rocket in the very direction which we had chosen, though at a great apparent distance. This last however seemed to be lessened by the sandy nature of the ground, for we only found it necessary to raise one foot and preserve as long as possible an equipoise on the other, which would thus carry us several yards without any exertion on our parts.

These signals having made us certain about our true line of march, I consented at last to leave Albistur, whose great weakness kept him back, and who had been some time urging me to descend in advance, leaving an Indian for his guide. In a short time I approached so near the body of clouds below, as to distinguish a fire shining faintly through them. At a quarter past nine I entered the cloudy screen, and soon emerging on the lower side I found myself near enough to give notice of my approach by loud shouts, which were echoed by a trio of voices from below, and the fires were increased to a brighter blaze while a volley of rockets welcomed our return. My fatigues were now all forgotten, and I bounded along through the prickly grass, insensible to its sharp points, and leaving my Indians far behind. It was half past nine when I reached Reymundo's encampment, after descending rapidly for four hours, a distance of at least three and a half, or four leagues. Tello had arrived only half an hour before me, after suffering great hardships in

making the circuit from the point where he left us. The whole party were quartered in the high grass west of the pile of bones. Tello was sheltered from the north-east air by a large rock, and buried under a load of cloaks and blankets; Valdez, overpowered by the sorroche, had retired to Cangallo. I ordered the fires to be freshened and rockets sent up in a perpendicular direction so as to traverse the haze and be a sure guide for Albistur, and then took up my quarters by the side of Tello. Albistur soon arrived and had need of all we could do for him in the way of refreshment and repose. For myself, I still felt no appetite, though I had eaten nothing more than two ounces of bread in the last sixteen hours. We had here some leisure to chat a little over the adventures of the day, and among these the track of our unknown predecessor and the ominous excavation were not among the least interesting to Tello, who stated to me that the neighbourhood of Arequipa had been very rich in silver at the time of the Incas. The Indians, according to him, preserved many traditions of this kind, and some were supposed to possess the secret of valuable mines now existing. To find these, many persons had followed Indians through deserts, and unsuccessfully explored the top of Pichu Pichu and the base of Chacheni. But no one had ever examined the Peak of Misté, because it was a volcano. Tello supposed therefore that the excavation we had seen might be the opening of an ancient mine, and was so full of this idea, that he left his warm bed to examine the specimens I had brought down with me, and said, on returning, that they had every appearance of a "Guia," or guide to rich ore. We fell asleep and discovered on waking, that the night had been extremely cold—the thermometer at sunrise was still at the freezing point. Mounting our mules we proceeded to the tambo, where they also got some refreshment after their long fast. After resting here a little while we proceeded towards the city, and arrived at two o'clock, finding many friends, who had been watching our return, and were now eager to hear the result of my tour. The love of the marvellous made them, however at first, unwilling to admit that the volcano had ceased burning and sent up no columns of smoke. Many regretted that I had not examined the south-west crest, and as many thought that I should have made more important discoveries, if I had passed within the sandy circle of the crater. The relation however of my companions' sufferings and my own, my hoarse voice, swollen eyes, burnt face, and frozen fingers,

prevented them all from wishing to attempt a more minute investigation with their own eyes; until the story of the mysterious visiter to the crater was told and the specimens from his excavation produced. These having been declared by connoisseurs to "promise gold," I should not have wanted for companions in a new ascent, and Tello and myself nearly determined to ascend again at a subsequent period, which circumstances however prevented. On the whole, although my friends at first seemed to doubt whether it would be found every day as I had found it, and whether it was proper to let themselves believe they were not in danger; yet I had the satisfaction to observe, before leaving Arequipa, that these doubts and fears gradually subsided, and a degree of hope and confidence with respect to the volcano succeeded to them, which certainly did not exist previous to my ascent.

*Boston, Nov.* 1823.

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Art. XL.—*Notices, by Rev.* Ezra S. Goodwin, *of Sandwich, of the effects in that vicinity of the Great Storm of 23d September*, 1815.—[*Mass. Hist. Coll.*]

The following notes on the storm or hurricane of September 23, 1815, and the extraordinary tide attending it, relate to a very small section of the country; being confined to the county of Barnstable, and particularly to that part of it contiguous to Buzzard's Bay.

At the present time, (December, 1818,) it may not be improper to arrange such minutes under three heads.

1. Notes on the wind and its effects.
2. Notes on the tide and its effects.
3. Notes on the more lasting influence of the sea-water on the land.

First. In regard to the wind and its effects. It began to rise in the latter part of the night preceding the 23d; about sunrise it had risen to a hard gale but was not then thought much more violent than many of the severe gales experienced in this region: It however continued increasing till about 10 o'clock, from which time till near 2 P. M. it was extremely high. The gale did not consist of an uniform current; but sudden gusts or blowings of wind, at short intervals; the

most severe of which were about 11 o'clock. The first abating of the gale was observed by longer intervals between the gusts. It subsided in the course of the afternoon, and by night the weather was quite moderate. The sky was cloudy throughout the day, but no rain fell. The course of the wind, early in the morning, was east; from which point it gradually changed to a few degrees west of south, and blew from the latter quarter when most violent.

But the gale was not by any means so severe in this region as in the parts of the country north and west of this. Some trees were torn up, but most of them stood in loose soil, or were so shaped, or exposed, that they could not resist any very high wind that should take them at advantage. Some buildings were prostrated, but they were old, or feeble; and, indeed, several buildings, which sustained this gale without damage, have since been blown down. No chimney was broken off or much injured. Salt works are more liable to injury from high winds than any other species of property on shore in this county; but they suffered little from the wind alone. A few covers were removed from their places and broken, and in some instances, where peculiarly exposed, some of the vats were lifted from the stakes on which they were built, and twisted or broken. It may afford a useful hint to remark, that a lot of salt works, in a very bleak and exposed situation, had been previously wattled with bushes, between the stakes which supported it, which so effectually defended it, that no damage was suffered; while a large, shallow reservoir, about eight inches deep, standing in front of another lot of salt works, was lifted, in a body, and cast over upon them in a very shattered condition; but its peculiar form and exposure rendered it a fit subject for this kind of violence. And, generally, this species of property, though from its constitution specially liable to injury from high winds, yet endured so little on this occasion, from the wind alone, that the loss sustained from this cause has been scarcely reckoned worthy of account. When this is compared with the prostration of forests and edifices, and the great destruction of property by the wind, in counties north and west of this, we must conclude, that the gale in this region was comparatively light.

It was still more moderate in the lower parts of the county; decreasing gradually, till at Provincetown it was called a hard blow, but by no means a hurricane.

2. In regard to the extraordinary tide and its effects.

The interior part of Buzzard's Bay communicates with several small bays or inlets, in most cases by narrow passages. In these small bays, and near the head of tide-water in Monimet or Back River, the water rose, during the gale, at least eight feet higher than is usual in the highest course of tides. In the open bay it was much higher. Seven miles below the places where the above observation was made, it is judged that the tide was ten feet or more above the common level of spring tides. It appears to have been higher, still lower in the bay.

The land is in many places low and level, and continues so at some distance from the shore, when it rises suddenly into hills. All the low ground was overflowed of course. The water from Buzzard's Bay approached so near to the source of a brook, which falls into Barnstable Bay, that observers have generally judged, that if it had risen fourteen or fifteen inches more, perpendicularly, it must have passed across the Cape, following the course in which a canal has often been projected, about two miles west of the village of Sandwich.

The tide in Buzzard's Bay is three hours earlier than in Barnstable Bay, which would bring high water in the former, on the 23d of September, 1815, at about 11 o'clock and 40 minutes, when the gale was at the greatest height. On this occasion, therefore, both wind and sea operated together, and much damage was done.

Coasting vessels are almost the only kind of shipping in this bay. Several of them were at that time moored near the shore at the landing places, where great quantities of cord wood had been collected, to be shipped on board them for market. Being a light kind of craft, they were scattered about in various directions, and most of them driven high upon the shore.

Dwelling houses are but thinly scattered over that region; but where they stood near the sea the inhabitants were obliged to abandon them and flee to high places for shelter. These houses being generally erected on ground a little elevated, none were destroyed; one only was filled with water as high as the chamber floor. No lives were lost.

Salt works, though they resisted the wind, suffered extremely from the tide. The business of salt making has been carried on to a great extent on the eastern shore of Buzzard's Bay. But all the works within the reach of this tide, were carried away. The shore was literally swept with the

besom of destruction. On the island of Mashena, a large amount of this kind of property was lost. The water washed away the salt works, apparently without an effort. A salt house connected with them, being partly filled with salt, maintained its position till the tide had risen nearly to the roof, when it was overset, and floated across the bay. The ruins of these works were found in the woods at Wareham. In one instance, a large lot of salt works was floated, in a body, the distance of several miles, without being broken. Had it been caught and brought to an anchor, it would probably have been saved, with but slight damage. It was, however, driven upon a craggy shore, where the tide left it, and it fell to pieces over the rocks; but the salt house, which sailed in company the whole distance, chanced to find a better resting place. It was lodged directly across a road, where it settled upon corner stones so well adapted, that its perfect shape was maintained. It was afterwards launched like a vessel, and conveyed back to its original position, without being essentially injured by the excursion. The place where it grounded is about nine feet above the level of common high tides.

After the flood was passed, it was striking to observe how small vessels, and these light fabrics, had been made the sport of winds and waves. Some of the coasting vessels were floated completely into the forest. One of these was lodged among trees so large, that they sustained it in an upright position, till it was relaunched, with very little damage. Another was lifted over a bluff and laid in front of a dwelling-house, as one might say, across the door-stone. The vessel proved a defence to the house, which might otherwise have suffered greatly. The wrecks of salt works appeared in some places to have been heaped together in fantastic mood, presenting strange appearances of ruins; of buildings partly finished, and left in that condition; and of the others, the design of which, in such spots, could not be conjectured.

The injury done in Buzzard's Bay was much greater than that in the Vineyard Sound. The waters in the latter place were not heaped up, as in the former. But the tide in Falmouth harbour was so high as to create much confusion, and do much damage among the shipping there. A brig was driven on shore at Hyannis; but below that place the wind was more moderate, and the waters had sufficient sea-room; so that little or no damage was done.

In regard to the immediate effect of the tide upon the soil and its productions. Grass was entirely killed. There was not

a green blade to be seen, in any place, over which the flood had passed. In a few spots, near running springs, some new shoots appeared in the course of the autumn; but on uplands, none grew till another season; and then it was not the same kind of grass which grew there before, excepting in a very few instances. Several cedar swamps were filled with sea-water, which, having no outlet, soaked into the ground. The trees in these swamps perished forthwith; the leaves withering and falling off in a very short time. In trees cut from these swamps during the winter following the storm, the sapwood had turned nearly black; and there is scarcely an instance in which a cedar tree survived the effect of this flood. Pine and oak trees suffered a similar fate, excepting a very few, which stood near the shore. They had perhaps grown accustomed to the influence of salt water, and could better endure it; but a very great proportion of them died. Most of the shrubs and bushes, over which the tide passed, perished also. It has been observed, that one or two species of laurel, and the common bayberry were but little if at all injured, and some of the swamp whortleberries survived. Apple trees were, generally, on such high ground, that the tide did not reach them. A few only were surrounded by the water, and none of them were so situated that the water could remain about them for any length of time. They were, however, as much exposed as many of the cedars which died; but the apple-trees survived, and yet live, though evidently stinted as to their growth. With these exceptions, the destruction of vegetable life was very general, if not universal.

A great part of the cultivated lands, in that vicinity, are in low places near the shore; they were overflowed of course. In fields where Indian corn was standing, the roots were, in most cases, torn out of the ground; and where this did not take place, the stalks were wrenched and twisted, and the spikes broken off. The soil was so washed in these fields, that they exhibited the appearance of a seashore, rather than of cultivated land. Indian corn, where it had previously grown hard or ripe, was fit for food; for some time the people washed it before grinding; but they soon discovered that the washing was unnecessary, as the grain had no taste of sea-water, or so little as to be disregarded. But where this grain had not already grown hard, it would not, though left standing in the field; it either perished in the husk, or very soon after it was taken out. It was a common remark, that no part of the plant could be dried by any means, and by far the greater part of the harvest was

lost, not being yet ripe. Potatoes and other roots, if left long in the ground, perished; but where they had ripened, and were taken up within a few days after the flood, and well dried, they were good, and were kept and used as usual, during the season.

It is the practice of our farmers to sow winter rye in August. This plant had, of course, advanced considerably in growth at the time of the storm. Where the salt-water passed over it, it was entirely killed; unless we except one or two spots in very low and wet ground; but in these, the rye was so much injured, as nearly amounted to total destruction. Some fields were immediately resown; in these, the rye sprung up, endured the winter, and produced a good crop. But the fences having been principally of cedar, were almost all swept off, and the fields laid common; and few people felt encouraged to commence the labour of the season anew, with the additional expense and trouble of procuring and setting up new fences.

Fresh water was, for a long time, a rarity of price. The wells were generally overflown and left full of sea-water. Watering places for cattle suffered a similar fate; and so extensive was the influence of the flood, that several wells and watering places, into which the tide-water did not run, were yet made salt. The water in them acquired the taste and quality of sea-water, and was totally unfit for domestic purposes. The inhabitants were obliged to transport this necessary article, for family use, from a great distance; and travellers who needed it were glad to receive it in a measure of the smallest capacity. In some wells near the shore, the water used to rise and fall with the tide, still remaining fresh; but the severe discipline of this flood changed their habit; the water in them remained at a fixed height, and salt.

When this extraordinary tide was sweeping over the land, the spray arising from it was very great. It is spoken of as having resembled a driving snow-storm, through which objects could be discerned only at short distances. But the leaves of the trees did not afterwards exhibit any of the dark red colour, (as if they had been scorched,) which was observed in more northern regions, and especially in the vicinity of Boston. The leaves of trees destroyed by the flood exhibited very soon the appearance of death, but not of having been burnt; neither was salt spray collected on window glass to any amount.

3. In regard to the more permanent influence of the sea-water on the land.

Very little rain had fallen for several weeks previous to the storm; the soil in this region, naturally inclined to dryness, was very dry. A large proportion of the salt-water, therefore, penetrated the earth, which may be said to have been saturated with it. Many persons have expressed an opinion, that the water of this tide was much more strongly impregnated with the ingredients of sea-water, than that of ordinary tides. Perhaps, with some limitation, this opinion may be correct, as there are several streams of fresh water emptying into Buzzard's Bay, which may diminish the strength of ordinary tide-waters; but would have but little influence on this occasion. Salt was observed to have crystallized in many places on the shore within a few days after this flood. This may in some measure account for the remarkable saltness of the wells and watering places. This saltness continued in them, unabated, till the first week of the following March. The winter had been severe, and the ground frozen very deep till the middle of February, when there were several weeks of moderate weather, with soft rains, which dissolved the snows and opened the ground; shortly after which, it was discovered that several of the wells and watering places were fresh. The water in these had been tasted but a few days previous, and was then as disagreeable as at first. The freshness must have taken place suddenly. After a succession of dry weather, these wells, &c. grew salt again, but not to the same degree as before; and it has been observed, that after heavy rains, they would be fresh, but become salt after dry weather; the degree of saltness diminishing from time to time. At the present period they are perfectly fresh; but some of them did not entirely recover until the opening of the ground in the spring of 1818; and in a large pond, which has but a very small outlet, the water still retains some taste of sea-water.

Several of the overflown fields were, in the spring of 1816, sown with oats, which produced a more abundant crop than ever was known in that region before. Indian corn flourished remarkably, as also spring grain; and the land, generally, was found in a much better state for tillage, than before it had been overflown. On grass lands, the effect was various. Grasses which had been sown, perished; and there grew in place of them the common wild grass of the country, which continues to keep possession, where the fields have been left

to the ordinary course of nature; but where they have been ploughed and sown again, good grass is produced. Generally speaking, whatever grasses were growing on level grounds, perished; and those of a poorer sort sprung up in their place. In several places where the land lay sloping toward the sea, the natural grass in pasture grounds was killed; and in the following year, clover grew there. In 1817 the clover decreased in quantity, and nearly disappeared in 1818. Mosses, also, were destroyed by the sea-water, and grass grew where they had been. Sea-water appears to have acted as an alterative, and may, perhaps, be found useful, in some cases, as a manure.

The effect of this flood upon the land is now nearly past; it has been of some temporary service to the soil; but this temporary benefit is by no means an equivalent for the destruction of property which took place at the time of the storm. The harvests were then generally in the field, and the annual produce of the salt manufactories had not been removed to a place of safety. The dependence of many families for their yearly subsistence was in a great measure lost; and much distress was brought upon the people in several respects.

## Art. XLI.—*Prof. Hausmann on the Geology of the Apennines.**

We have received from Professor Hausmann, of Gottingen, a copy of his valuable essay on the geological structure of the Apennines, read before the Royal Society of Gottingen, of which the following is a brief analysis. [J. W. W.]

The first section contains an account of the general appearance of the Apennines. The most elevated point of the range is 8934 feet above the level of the sea. The second section entitled "Apenninorum constructio interna" embraces

* De Apenninorum constitutione geognostica commentatio, in consessu Soc. Reg. Scient. D. XVI. Novembr. An. MDCCCXII, ad anniversarium solemne celebrandum habito, recitata a IO. Frid. Lud. Hausmann. Gottingae MDCCCXXIII.

the geological description. From this it appears that the structure of this mountain chain is peculiarly simple, containing no rock of any consequence, except a white limestone of uniform aspect, rarely containing foreign substances or petrifactions. In the immediate neighbourhood of the Alps, however, and in the southern part of the chain in Calabria, there are rocks of older formation. In the lateral chains there is considerable variety, and transverse sections of these mountains often present alternations of various rocks.

The Apennines differ from many other mountains in this, that in many places where strata of different formations are observed, the more ancient are found neither in the centre of the transverse chains, nor in the more elevated parts, but on the sides and at inferior elevations.

From analogy we should expect primitive rocks in these mountains, but from the observations of Prof. Hausmann they appear to be wanting, except towards Calabria. The observations of Viviani, Spadoni, Santi, and others, are noticed, but they do not appear to be confirmed by those of our author, who however offers no decided opinion of his own, in regard to the formations of Giglio, Elba, &c. which these writers have considered granite and gneiss.

The transition formations are the most extensive and important; comprising the Apennines of Genoa, Lucca, Modina, a part of Tuscany, and various other places, always reposing on primitive rocks. The rock named *macigno* and *pietra serena*, which is extensively used in Florence for architectural and ornamental purposes, appears to be a variety of grey wacke, and occurs in all parts of Italy where the transition rocks are found. The grey wacke in different parts of Italy, observes Prof. H. is not so varied in its grain, and in other respects is more simple than that of Germany. Quartz is the predominating ingredient, together with particles of black siliceous slate, and scales of silvery mica. The cement is present in small quantity, and is even sometimes wholly wanting, in which case the portions of quartz lose the granular form, and constitute a continuous mass, making a transition from grey wacke to quartz rock. At other times it passes into clay-slate and into compact limestone.

Clay-slate, flinty-slate and talc-slate are next noticed; the latter occurring more frequently and in larger masses, passing on the one hand into clay-slate, and on the other into chlorite-slate. When mixed with quartz it forms the "saxum fornacum", or *Gestellstein*, (a kind of oven-stone.) This rock was

noticed by Saussure* and St Fond†, between Genoa and Finale, alternating with compact limestone and clay-slate, and is hence inferred to be of secondary formation, as is likewise the gneiss observed by Saussure‡ near Voltri.

Compact limestone, which is so important in the geological structure of the Alps, is not less so in that of the Apennines. It alternates with grey-wacke and clay-slate; in some places passing into those rocks. Its colours are various, but grey is the most common. It contains but few organic remains; a rare specimen of an Ammonite was met with by Micheli§, which is preserved in the collection of Professor Targioni at Florence.

When the compact limestone is mixed with quartz and mica, it constitutes the *Pietra forte*, much used at Florence and other places for paving the streets.

The transition rock of most interest in these mountains is the *brecciated limestone*. Some important observations upon this rock have been made by Brochant‖. It is apparently composed of fragments of limestone, of various shapes and colours, united by a calcareous cement, sometimes mixed with talc, clay-slate, and other matters. Its colours are strongly contrasted, and it has sometimes the character of the beautiful African breccia. In other instances it approaches the antique *Cipolline* marble. Where the nature of the fragments does not differ greatly from the cement, there takes place a transition into compact limestone, or marble, which was noticed near Carrara, where the brecciated marble alternates with the compact.

Professor Hausmann describes the appearance of the brecciated limestone of the Apennines, as rough, and traversed by numerous fissures, which are particularly conspicuous where the cement is softer than the included fragments, and being acted upon by air and moisture, is broken down and washed away. This most beautiful breccia is known by the name of marble of Seravezza, and is much used for ornamental purposes. Our author supposes it to be the variegated stone referred to by Strabo¶.

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* Voy. dans les Alps. Vol. iii. p. 167.

† Annal. du Mus. Vol. xi. p. 222.

‡ Voy. dans les Alps. Vol. iii. p. 159.

§ Ferber's Briefe, p. 327.

‖ Jour. des Mines. N. 137. p. 321.

¶ Geog. lib. v.

The celebrated marble of Carrara is considered by Prof. H. as belonging to the transition formation, contrary to the opinion hitherto maintained by geologists. It is connected with and passes into the brecciated limestone and grey-wacke, and these rocks alternate more or less with each other. This marble forms high mountains, with steep acclivities, and narrow vallies ; the rocks are destitute of vegetation and distinguished at a great distance by their snowy whiteness.

The colour of the Carrara marble is injured by exposure, acquiring a brownish tinge probably from a small quantity of iron which it contains. Iron pyrites are found in it, together with calcareous spar and rock crystals.

Professor Hausmann observes, that when the Carrara marble is cut into long and thin pieces it is flexible like some varieties in North America.

The next rock described is the *Gabbro* of Von Buch* ; this is one of the most beautiful and remarkable rocks of the secondary formation. Prof. H. observes, that, although from his examination of this rock in the Apennines, he is satisfied that it is not a primitive rock, yet he would not maintain that Gabbro is in every case a member of the transition formation. Under the term Gabbro he includes serpentine, the Gabbro of the Italians, and a rock called in Florence granitone, composed of saussurite and diallage (Euphotide of Haüy). These rocks are shown to be but varieties of the same, often containing asbestos, in which case the hardness of the compound is diminished, and the quantity of magnesia in it is increased. Four varieties of Gabbro are described, viz.

1. Granular crystalline Gabbro, containing quartz, hornblende, prehnite, and a substance which has not been examined. This variety passes into jasper.

2. Porphyritic Gabbro, including the *Nero di Prato.* The principal part of this variety is serpentine, in which particles of schillerstein are seen.

3. Spotted Gabbro, principally serpentine with compact globules of saussurite.

4. Common Gabbro, or serpentine.

These observations do not exhibit any uniform regularity in the relative situation of the transition rocks of the Apen-

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* Ueber den Gabbro, von Leopold Von Buch. Magazin der Gesellsch. naturf. 1810, II. p. 128.

nines; but they are most probably to be referred to one epoch. The direction and inclination of the strata are very various. Prof. H. thinks it not improbable that these rocks are a continuation of the secondary formations of the Alps.

After remarking that the upper Apennines exhibit a more varied structure than the other parts, Prof. Hausmann proceeds to describe the rocks between Tuscany and southern Calabria. The compact limestone already noticed, constitutes the most prominent geological feature, and is stated to resemble the white Jura limestone. It does not contain beds of oolite, which are often met with in the latter, but calcareous and argillaceous marl and hornstone. Professor Hausmann observes that it is difficult to decide whether the limestone of the Appennines is to be referred to the newest secondary formations, to which the Jura limestone belongs, as there are no super-incumbent formations, nor petrifactions sufficient to determine the question. The transitions and alternations of the strata increase the difficulty. From various considerations, however, he is inclined to refer the principal part of this limestone to the same formation as the Jura limestone. If this opinion is correct, the lower part of the plain of the Po with the Adriatic sea, is to be considered as a longitudinal valley extending from N. W. to S. E. in this limestone formation. The principal boundaries of the formations have the same direction, with some little interruption. The continuation of the line of the white limestone of the Apennines above Bologna, towards the N. W. is found near Arona, in the same limestone. The line of the transition mountains, which begins in Calabria, skirts cape Circeo, and with increasing breadth stretches through the southern part of Tuscany to the upper Apennines, and thence to the Alps. The primitive rocks begin in the southern extremity of Calabria, and in Sicily, touching either the granite of Giglio and Elba, or, if this rock belongs to the transition formation, probably the primitive rocks of cape Corso in Corsica.

The tertiary mountains are next described, and, for the most part, are so completely separated from the Apennine limestone, that no transition can be discovered. There are, however, some exceptions in the territory of Otranto, where a transition was first noticed by Brocchi.

The tertiary formations are distinguished by Professor Hausmann into *more general* and *more local.*

The *more general* consist of angillaceous marl, passing on one side into slate-clay, and on the other, into sandstone;

plastic and slaty clay; sandstone; conglomerate; and sand. The latter is always the newest. In these formations fossil organic remains occur, with bones of colossal animals, and shells. Bitumen, sulphur, pyrites, barytes, and strontian are also met with. The sulphur is often beautifully crystallized.

The *more local* tertiary formation consists of gypsum, calcareous tuffa, and volcanic tuffa. The alabaster which is wrought at Florence into various ornamental articles, belongs to the gypsum of this formation. The greater part of the Apennines being composed of limestone, it is easy to explain the production of the calcareous tuffa, at their base and in the vallies. The celebrated Travertina marble is a tuffa of this kind. The quantity of calcareous tuffa in Italy, and its varied appearance are wonderfully great. Prof. H. points out some of the most remarkable localities. He remarks that different local formations of this substance can be distinguished; some having been formed at the bottom of the sea, as is proved by the marine remains found in them; while others have resulted from the sediment of fresh-water rivers and lakes. The fresh-water strata exhibit also proofs of difference in age. Those which alternate with the volcanic tuffa, as seen in some of the hills of Rome, the Aventine for example, and in the vicinity of the city, are most ancient. Those strata which cover the volcanic tuffa, and the tuffa upon which Tivoli is built, are of more recent origin. The newest formation is that daily forming, as at the baths of St Philip, &c.

The *volcanic tuffa*, although composed of volcanic matter, in the state in which it is now observed is to be referred to the aqueous depositions, as has been proved by Von Buch in his excellent remarks upon the country about Rome*. It appears to be confined to the south-western side of the Apennines, and is separated into two portions, one of which extends from the neighbourhood of Rome to the Pontine marshes and vicinity of Bolsenna. The other portion, which is less extensive, occurs about Naples. In the first, leucites occur, but are altogether wanting in the second, into the composition of which, felspar enters.

The volcanic tuffa is of later formation than the marls, sandstones, and sand before noticed; as is well seen in the

* Geognost. Beob. II. p. 60. 202.

neighbourhood of the Vatican, where the sand is full of marine shells and rises from under the tuffa. This fact was first described by Von Buch.

Professor Hausmann concludes his memoir by remarking, 1st, that there are no *true volcanic* rocks, nor rocks of the trapp formation (*Trappgebirgsarten*) in the central chain of the Apennines, although Ferber* and some other writers have advanced an opposite opinion. 2d, That the *true volcanic* formations are found only on the south-eastern side of Italy, with the exception of the extinct volcanic mountain Vulture. The greatest extent of the volcanic rocks is in the line of those of more remote origin, and but a part of them, as Vesuvius, the extinct volcanoes of Nemi and Albano, and the formation near Borghetto, approach the Apennine limestone.

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## Art. XLII.—*On the Construction of an Air Barometer.* By Henry Meikle. [*Philos. Mag.*]

This instrument, which has some resemblance to an air-thermometer, consists of a hollow ball of glass containing air, from which a vertical tube, open at bottom, descends, and terminates in a cistern of mercury†. The mercury is likewise designed to occupy a part of the tube, more or less, according to the state of the atmosphere. Another tube, equal to the former, and placed close by its side, is also immersed in the quicksilver, though open at top. But in order that the air in the ball and first tube may always be readily brought to the same tension as the air without, the cistern consists of a leathern bag, inclosed in a box, the bottom of which is moveable by a screw precisely as in a mountain-barometer. The mercury in the cistern is, however, open to the external air no where but through the tube, which is open at top.

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* Briefe aüs Wälschland, p. 430.

† Dr Hook long ago employed air in the construction of his marine barometer; but that instrument is very different from this in various respects.

Now it is manifest, that if the screw at the bottom is turned till the mercury in both tubes stands at the same height, the elasticity of the air within will just balance the weight of the atmosphere: and since in this case the spring of the included air, allowing for change of temperature, cannot sensibly differ from being inversely as its bulk, the space which it occupies will always be inversely as the atmospheric pressure. If, therefore, the tube connected with the ball, or a scale by its side, is graduated, and numbers attached proportional to the contents of the ball, and of that part of the tube which lies above them, these numbers being inversely as the densities, or inversely as the mercurial altitudes in a common barometer, are also ordinates to a logarithmic curve, equal that employed in the usual mode of investigation; and hence the difference of their logarithms has still the same proportion to the difference of elevation*; wherefore these numbers will be equally convenient for the purpose of calculation, as the numbers on a common barometer†. The mode of applying a vernier, and of reading off the observation, being so nearly the same as in a portable barometer, need not here be particularly described; and it is scarcely necessary to remark, that since the surface of the included air in contact with the mercury is so very small, the temperature of the mercury cannot sensibly affect this instrument.

If the air-ball be quite exposed to the air, and be at the same time kept in the shade, it may be presumed that the included air will be at least as near the temperature of the surrounding air as the detached thermometer is; and if so, an attached thermometer may be dispensed with. Indeed, after all the precautions that have been used, it may be questioned whether the thermometer attached to a mountain-barometer may not sometimes differ considerably from the temperature of the mercury in the barometer, especially when the two thermometers themselves disagree.

A difference in the temperatures of the included air at the two stations, will affect the elevation so much more than the

* Or, more simply, the difference of the logarithms of two numbers is equal the difference of the logarithms of their reciprocals: the logarithms of any number being the arithmetical complement of that of its reciprocal.

† These numbers are equally well suited to the very ingenious method of computing the elevation given by Dr Robison, in which no tables are required. The only difference is, that here a correction is to be applied for the temperature of the included air, instead of that of the mercury.

same difference would in the temperature of the common barometer, as the effect of heat on air is greater than on mercury. Yet as the temperature of the air seems to admit of being ascertained with greater precision than that of the mercury, it may be presumed that this instrument will not on account of heat be less to be depended on than the mercurial barometer.

If a lighter fluid could be employed in place of mercury, the sensibility of the instrument might be greatly increased; but the evaporation, viscidity, capillary attraction, or some such defect, almost precludes the use of any thing else. The range or scale of this barometer might be made of almost any magnitude, though it is doubtful if its sensibility can be increased quite in the same proportion. Still, when of large dimensions, its sensibility may much exceed that of the common barometer; but a very large instrument would hardly deserve the name of portable. It may however be at least as sensible as the mercurial barometer when only of about half its length.

If the tube connected with the bulb, in place of being cylindrical, were to widen downward, so that the numbers on an attached scale of equal parts might be the logarithms of those already mentioned, the elevation could be obtained with greater facility: but the formation of such a tube with accuracy would be a matter of some difficulty; and unless the divisions are equal, it would be still more difficult to apply a vernier to the scale, though it is by no means impossible to do so.

## Art. XLIII.—*Remarks on* Mr Crichton's *method of ascertaining the degree of temperature at which water is at its maximum density**. By James Dean, Esq. *Prof. Math. and Nat. Phil. in University of Vermont.*

It seems to me that Mr Crichton, in attempting to determine the temperature of water at its maximum density has fallen into two capital mistakes. The first is, inferring from the relative expansions of glass and water through the *whole scale* from freezing to boiling, that the expansion of water

* See Bost. Journ. No. III. p. 233.

was proportionally greater than that of glass in every *part* of that scale; whereas, when near its maximum density, water expands very little, and from that temperature to 4° above it, or from 39° to 43°, its expansion is *less* than the *cubic* expansion of glass in the same part of the scale, according to the experiments of Blagden and Gilpins.

The other mistake is, concluding that the error arising from the expansion of the glass, whatever it might be, is corrected by an opposite effect on the indication, above and below the required temperature. Let us suppose some imaginary body whose dimensions are not affected by heat, and of such density as to just sink at 6° above or below the temperature of the greatest density, and a glass ball of the same buoyancy when exactly at that temperature. If these bodies are placed in water at this temperature, and the temperature be reduced, the glass contracting will become specifically heavier than the constant body, and sink perhaps at 4° below the temperature required instead of 6°; on warming the water the glass expanding becomes specifically lighter than the constant body, and does not sink till the temperature rises 8° above the point proposed instead of 6°, thus conspiring to produce an erroneous result.

*Burlington, Vt. Oct. 23, 1823.*

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Art. XLIV.—*Chemical examination of a fragment of a Meteor which fell in Maine, August,* 1823, *and of Green Feldspar from Beverly, Mass.* By John W. Webster, M. D. &c.

This aerolite fell at Nobleborough, in the state of Maine, on the 7th of August, 1823, between 4 and 5 o'clock, P. M.

The only information which I have been able to obtain of the attending phenomena, is from the papers of the day, and a communication of Professor Cleaveland, which is published in the American Journal of Science, vol. vii. p. 170; this account, he informs me, was obtained at his request by a gentleman of intelligence in a personal interview with Mr A. Dinsmore, who was at work near the place where the aerolite struck. "Mr Dinsmore's attention was excited by hearing a noise which at first resembled the discharges of platoons of soldiers, but became more rapid in succession. The air was perfectly calm; and the sky was clear, with the exception

of a small whitish cloud, apparently about forty feet square, nearly in his zenith, from which the noise seemed to proceed. After the explosion, this little cloud appeared to be in rapid spiral motion downwards, as if about to fall on him, and made a noise, like a whirlwind among leaves. At this moment, the stone fell among some sheep, which were thereby much frightened, jumped, and ran into the woods. This circumstance assisted Mr D. in finding the spot where the stone struck, which was about forty paces in front of the place where he was standing. The aerolite penetrated the earth about six inches, and there meeting another stone, was broken into fragments. When first taken up, which was about one hour after its fall, it exhaled a strong sulphureous odour. The whole mass, previous to its fracture, probably weighed between four and six pounds. Other fragments of the same meteoric stone are said to have been found several miles distant from Nobleborough."—(*Amer. Journ.*)

To the politeness of Dr George Hayward I am indebted for a fragment of this meteor.

Externally the specimen was in part covered with a thin, semivitrified crust or enamel of a black colour, the surface of which was irregular and marked with numerous depressions, presenting every appearance of having been subjected to intense heat. The crust was hard, and yielding with difficulty to the knife. The quantity of this crust which the small fragment I obtained afforded, was not sufficient to allow of any separate analysis of it.

The mass of the specimen had a light grey colour, interspersed with oblong spots of white, having somewhat the aspect of decomposed leucite, giving it a porphyritic aspect. Throughout the stone minute points of a yellow substance, resembling olivine, were distributed, with microscopic points of a yellow colour, which I imagine were sulphuretted iron. The cement by which these substances were united was of an earthy aspect and soft texture, readily broken down by the fingers. The general appearance of the mass was precisely like that of some of the volcanic tuffas.

The specific gravity was remarkably low, being but 2.05*.

Before the blow-pipe it exhaled a sulphureous odour, but was not fused.

The specimen was reduced to powder, and submitted to the action of a magnet of considerable power, but no attracta-

* The lowest specific gravity of any meteorolite on record is that of the St Etienne specimen, which is but 1.94.

ble particles were separated. A portion was heated to redness on a platina spoon; it emitted the sulphureous odour, and its weight was diminished rather more than 21 per cent.; the residue acquired a brown colour. It was again presented to the magnet, but nothing was attracted.

(1) One hundred grains of the stone were introduced into a tubulated retort, with dilute muriatic acid; the beak of the retort was plunged into a solution of acetate of lead, slightly acid, and contained in a small tubulated receiver. A moderate degree of heat was applied, and the digestion continued for twelve hours. A slight quantity of sulphuret of lead was formed, but not sufficient to admit of being collected and weighed.

All action upon the powder having ceased, the fluid was turbid, holding a substance, which I imagined to be the sulphur, in suspension; at the bottom was an undissolved residuum.

(2) The fluid was carefully separated and filtered; the substance remaining upon the filter was washed with distilled water, and thoroughly dried. It proved to be sulphur, and weighed 18.3 grains.

(3) The insoluble residuum was mixed with pure potash, and exposed in a silver crucible to heat sufficient to cause the fusion of any silicious earth. The crucible being placed in an evaporating dish, hot distilled water was poured upon it until the contents were completely removed. The resulting fluid was treated in the usual manner with muriatic acid, with the addition of the acid which had been digested upon the stone in the first instance. The quantity of silex obtained, after calcination, amounted to 29.5 grains.

(4) The solution, the bulk of which had been considerably augmented by the addition of the water with which the precipitate (3) had been washed, was carefully evaporated to rather less than a pint. Carbonate of potash was added until it ceased to produce any precipitate; the whole was moderately boiled. When the precipitate had completely subsided, the supernatant liquor was decanted, and distilled water substituted. The precipitate was collected and boiled with pure potash; the liquor after filtration was treated with muriatic acid in excess, from which carbonate of ammonia threw down a flaky precipitate, and was added until the alkaline taste predominated. The precipitate thus obtained, after ignition, weighed 4.7 grains. To satisfy myself of the nature of this substance, it was treated with sul-

phuric acid and potash; crystals of alum were obtained, and it was therefore alumina.

(5) The residuum which had resisted the action of the potash was digested in diluted sulphuric acid; after expelling the excess of acid, pure water was poured upon the remaining solid, in order to dissolve any sulphate of magnesia and metallic sulphates.

To discover if any lime was present in the solution, it was treated with alcohol, which afforded a slight trace of that earth.

(6) The solution, after the addition of more water, was acidulated with sulphuric acid, and the metallic oxides were precipitated by the bicarbonate of potash. The magnesia was separated by pure potash, and after ignition weighed 24.8 grains.

(7) The precipitate (6) was boiled in nitric acid, in order to acidify any chrome present in it, which was afterwards by the addition of potash converted into a soluble chromate. On adding muriatic acid the chrome was obtained in the state of an oxide, sufficiently characterized by its beautiful colour. After being well dried, it weighed 4 grains.

A portion of this substance was subsequently exposed on charcoal with borax to the action of the blow-pipe, and its nature satisfactorily proved.

(8) The matter remaining, after the separation of the chrome, was re-dissolved in muriatic acid, and the iron was thrown down by ammonia. After washing and drying, it weighed 14.9 grains.

(8) The remaining solution was now evaporated, the ammonia driven off, and the precipitate which proved to be nickel, weighed 2.3 grains.

The composition of this meteoric mass is therefore

| | |
|---|---|
| Sulphur - - - | 18.3 |
| Silex - - - | 29.5 |
| Alumina - - - | 4.7 |
| Lime - - - | a trace |
| Magnesia - - - - | 24.8 |
| Chrome - - - | 4. |
| Iron - - - - | 14.9 |
| Nickel - - - | 2.3 |
| | 98.5 |
| Loss - - - - | 1.5 |
| | 100. |

*Green Feldspar from Beverly, Massachusetts.*

This mineral is peculiarly interesting, as another instance of the great similarity existing between the minerals of this country and those of the north of Europe. The only specimen which I have seen from this locality, is connected with quartz and mica, constituting a perfectly characterized granite. The colour of the feldspar is of a lively verdigris green, the fracture is foliated with a high degree of lustre, and the concretions, or imperfect crystals, are from a quarter to half an inch in diameter. The intermixture of the quartz, which is white, with the brown mica, and the green feldspar produces a beautiful effect.

My first object in submitting the green feldspar to a chemical examination was to ascertain the proportion of alkali it might contain. For this purpose one hundred grains reduced to an impalpable powder were mixed with twice their weight of boracic acid, as proposed by Sir H. Davy. The mixture after fusion in a platina crucible, was digested in dilute nitric acid. After separating the silicious earth, the bulk of the solution was reduced by evaporation super saturated with carbonate of ammonia, and boiled; after filtration nitric acid was added to the liquor, which was again filtered, and exposed to a temperature sufficient to decompose the nitrate of ammonia that had been formed. The salt obtained was nitrate of potash, and weighed 23.6 grains, equivalent to 11.1 of alkali.

Another portion of the specimen was treated in the usual manner. The details of the processes it is unnecessary to repeat, as they presented nothing peculiar. The composition of this feldspar was found to be as follows:

| | |
|---|---|
| Silex - - - - - | 72. |
| Alumina . - - - | 10.1 |
| Lime - - - - - | 1.2 |
| Magnesia - - - | 3.2 |
| Iron - - - - - | 2. |
| Chrome - - - - | a trace |
| Potash - - - - - | 11.1 |
| | 99.6 |

In some preliminary experiments I detected fluoric acid, but on more minute examination of the specimen, small portions of distinct fluate of lime were found connected with the feldspar; the source of the acid consequently became evident. I also noticed some metallic particles in the compound, which are probably oxide of titanium.

## Art. XLV.—*Some account of the discovery of the Fossil bones of the Mastodonte or great American Mammoth, and of the Anatomical character of that Animal.*—By John Ware, M. D.

(Continued from p. 269.)

The bones of the mammoth, found so abundantly in North America, are rare every where else. The teeth brought from South America, and those found upon the ancient continent, with the exception of three, belong to different species, though to the same genus with the great animal of the Ohio. The limits, upon the surface of the earth, within which these remains are to be found, have not been exactly ascertained. It is a remark of Mr Jefferson, that, from the thirty-sixth degree of north latitude, "the further we advance north the more their vestiges multiply, as far as the earth has been explored in that direction; and it is as probable as otherwise, that this progression continues to the pole itself, if land extends so far. The centre of the frozen zone then may be the acme of their vigour, as that of the torrid is of the elephant*". According to Dr Barton, they have not been found, except in some few instances north of 43°, and this range would correspond best with what were probably the food and habits of life of the animal.

These remains are remarkable among all fossil bones, for the very perfect state of preservation in which they have been generally found, and for the little change which appears to have taken place in their situation, form, or structure for many ages. They have no appearances like those produced upon substances which have been exposed to the waves of the sea, and rolled among stones and sand so as to produce a rounding or wearing effect upon their projecting points. They are near the surface of the earth, generally within six feet, and seem to have remained near the very spot where the animals died. Those which have been discovered on the river Osage, were found always in an upright posture, as if the animal had been simply overwhelmed and buried in the sand.†

* Notes on Virginia.

† The following account is given in the New York Medical Repository, Hex. 1, vol. 4, in a letter from Sylvanus Miller, Esq. to one of the editors, of the places in which the skeletons of Mr Peale were discovered.

"The places where these skeletons have been discovered are generally called marl-pits, and are low, sunken places, very wet and miry. The

It was to have been expected that the aborigines of America would occasionally have taken notice of objects so remarkable as these bones, and would entertain, at least, some vague notions of the nature of the animals themselves to which they belonged. Accordingly we find that there have been, among the North American Indians, several traditionary accounts of their former existence. Mr Jefferson relates, that they believe the mammoth to have been carnivorous, and that he still exists in the northern parts of America. The history of the tradition of the Delaware tribe on this subject, as delivered by one of their chiefs, to the governor of Virginia, is well known; but is in itself so remarkable, and at the same time so poetical, as to be well worthy of a repetition here. They assert that it has been handed down to them from their fathers; "That in ancient times a herd of these tremendous animals came to the Big Bone Licks, and began an universal destruction of the bear, deer, elks, buffaloes, and other animals which had been created for the use of the Indians; that the Great Man above, looking down and seeing this, was so enraged that he seized his lightning, descended on the earth, seated himself on a neighbouring mountain, on a rock, on which his seat and the print of his feet are still to be seen, and hurled his bolts among them till the whole were slaughtered, except the big bull, who, presenting his forehead to the shafts, shook them off as they fell; but missing one at length, it wounded him in the side; whereon, springing round, he bounded over the Ohio, over the Wabash, the Illinois, and finally over the great lakes, where he is living at this day."

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hole which had been made to procure this skeleton, lately discovered, was so nearly filled with water, that the nature of the earth and the colour could not be ascertained otherwise than by the earth on the banks or borders of the hole. The draining of these places has been only attempted about eight or nine years. The bones here discovered lay buried about ten feet under this marl and earth, which generally consists of five different strata: 1. the common earth found in low meadows; 2. a very black and rich earth, deemed good for manure; 3. a small stratum of blue clay; 4. a stratum of white marl; and 5. a stratum of grey or black marl; at or near the bottom of which, these bones are discovered, and some of them sunk into the earth some inches below the marl. These marl-pits are numerous, and very few have been drained."

In an account of mammoth bones found on the banks of York river, about six miles east of Williamsburgh in Virginia, Bishop Madison remarks; that the strata on which the bones rested were alluvial, that they lie in the marsh-mud or are sunk beneath it; and that the earth surrounding them is penetrated by great quantities of the roots of the cypress-tree, which probably grew upon the former surface of the earth at this place.

A Mr Stanley, carried by some Indian tribes over the mountains, west of the Missouri, to a river which runs westwardly, relates "that these bones abounded there; and that the natives described to him the animal to which they belonged as still existing in the northern parts of their country; from which description we judged it to be an elephant*". The Shawanese have a tradition, that in former times, when the animals to which these enormous bones belonged, were in existence, there was also a race of men of prodigious size, corresponding to them in strength and stature; but that the Great Spirit being offended, destroyed both men and animals with his thunder.

Of the various opinions entertained by philosophers and anatomists of the nature of the animal or animals, to which these bones belonged, some account has already been given in the preceding part of these remarks. They have been supposed to belong to the whale, to the elephant, and to the hippopotamus; to a carnivorous, to a herbivorous animal, and to one of a mixed character; to an animal with a trunk, and to one with a long pointed snout. But generally speaking writers have indulged rather in loose and hasty conjectures, than in accurate investigations. Had not the subject of fossil bones and extinct species been new, anatomists would not have hesitated to consider at once all the bones as belonging to one and probably an extinct animal, instead of searching among known and living species, for a conjunction of parts which had never been known to exist together—or attributing to several different species, those among these remains, which most nearly resembled their particular form or structure. It was not till the learned and truly scientific inquiry into this subject by Cuvier, that the difficulties which surrounded it were removed, and the obscurity in which it was enveloped, dissipated. Of this inquiry, as detailed by him in the Annals of the Museum of Natural History, I propose to give such an analysis, as will be sufficient to put the reader in possession of the principal facts upon which the received opinion of the form, size, and structure of the mammoth has been founded.

He enters into an examination of all the parts of the skeleton distinctly, and for the most part in the order of their importance, as affording indications of the structure and character of the animal itself; and as every thing about it

* Notes on Virginia.

shows its close relation to the elephant, a comparison of its remains with the bones of that animal is instituted with regard to almost every part.

1. The molares or grinders. The form of these teeth is their most important characteristic. The crown is generally of a rectangular shape, but the proportion of its length to its breadth is different in different teeth. The grinding surface of the crown is divided by a number of furrows, from two to four, of considerable depth, crossing the breadth of the tooth, and dividing it into several eminences which are each subdivided by another furrow, of less depth, running at right angles to them along the length of the tooth, and subdividing each of them into two nearly conical eminences. There are then upon the surface of each tooth a number of these pyramidal or conoidical projections disposed in pairs. These differ essentially from those upon the teeth of carnivorous animals, since in these last there is no broad surface studded with eminences, but a sharp cutting edge, notched into teeth, for the simple and very obvious purpose of cutting or tearing their meat.

The teeth differ from the molares of the elephant, in the greater depth of their furrows, which renders the eminences upon their surface larger and more prominent. To this circumstance it is to be attributed, that in the elephant the surface is soon worn nearly smooth, so as to leave no other projections than are occasioned by the lines of enamel, which resist to a greater degree than the soft bone the process of mastication, and therefore cause a degree of irregularity. Whilst in the mammoth, the surface would wear away more slowly and retain for a longer time the conical protuberances which give it its peculiar character.

The tooth of the mammoth consists merely of the common internal bony substance surrounded by a simple layer of enamel. It has no covering of cement or cortical substance, such as that which surrounds the tooth of the elephant, enveloping it as a layer of tartar sometimes envelops a human tooth, and uniting together the different laminæ of which it is composed. In this particular the mammoth approaches very nearly to the root-eating animals, instead of the purely herbivorous, and must probably have made the same use of his teeth as the hog and hippopotamus, and fed upon roots, tender vegetables, and aquatic plants.

The teeth differ from one another, in the number of their conical points, and in their comparative length and breadth. As respects the number of their points, they have

been found with six, disposed in two rows of three each; with eight in two rows of four; with ten in two rows of five each, and a single one at the posterior end of the tooth. The teeth with six points are always found the most worn; all of them half way down the eminences at least, and many entirely down to their bases. Those with eight points are less worn, but more so than those with ten, which have generally undergone but little alteration of shape. The six-pointed teeth are situated in the anterior part of the jaw, and must have appeared earlier than the others. It is not improbable that a grinder with four points preceded this, but that it was worn away and lost at so early a period of life, as never to have been observed among any of the bones which have been discovered.

The mammoth then had four, or, at any rate, three different sorts of molar teeth; and there must have been this number on each side of each jaw. Consequently it would have in the whole twelve or sixteen of these teeth. They could not, however, have been all in the jaws at once, but must have succeeded one another like those of the elephant, which has in all thirty-two grinders, yet never at any one time more than six or eight in actual use.

They do not follow one another, like human teeth, by springing up in the place of those which have fallen out, in consequence of an absorption of their fangs. The new tooth is formed behind the old, and succeeds it by pushing forward into its place. The six-pointed tooth appears first. After this has been used for some time and become a little worn, a second begins to grow behind it, which has eight points, and comes at length to be used with it. But by the time that the second has come fairly into use, the first is very considerably worn away, and after awhile falls out. The same process then goes on with regard to the third tooth. The second is pushed forward in the jaw to take the place of the first which has fallen out, and the third, with ten points, springs up behind it. Gradually the second is worn away as the first had been before it; it becomes useless, falls out, and leaves only the third and largest to perform the office of mastication alone. That this was the course taken in the dentition of the mammoth, is gathered from the state in which the teeth are found in the different jaws which have been discovered, and from the analogy of the elephant. Thus where the eight and ten-pointed grinders are both found in the same jaw, the former is much worn and almost destroyed by attrition, whilst the latter seems barely to have

been used at all. Where the six and eight-pointed teeth are found together, the same relative effect has been produced upon them. In the elephant, which has, first and last, thirty-two teeth, they succeed one another precisely in the same way, the new teeth becoming larger and longer as the age of the animal increases, till at length only one remains of the eight which belonged to each side, but this of a size sufficient to fill up the whole jaw and perform completely the office of mastication*.

In youth then, the whole number of effective teeth in the mammoth is at no time more than eight, and in age this is reduced to four, as happens to the elephant. The crowns are formed first, and push through into the mouth, before the fangs are much developed, so that the fangs are not found perfect except in those teeth of which the crown is almost worn away. This growth of the fangs probably keeps pace with the loss of substance in the crown, occasioned by mastication. As they increase in length, instead of striking deeper into the socket, they push the tooth further out of it, and thus maintain it at its original level, in spite of its loss of substance. In this way, when the tooth has become worn down nearly to the origin of the fangs, they become useless and fall out.

The molares differ very much, of course, in length, in breadth, in depth, and in weight, both according to the number of points, the degree of attrition to which they have been subjected and the degree of development of their fangs. The length and breadth do not bear the same relation to each other in all teeth. The long ones are sometimes very narrow, and the wide ones very short. The length of different teeth varies from about four inches to nearly nine; and their breadth from three to four. Their weight has been variously stated from one or two pounds to seventeen. Probably the largest are as much as ten or twelve pounds in weight.

2. The lower jaw is destitute both of incisive and canine teeth, and has a long pointed extremity which terminates

* In the Atheneum of this city is contained the skull and under jaw of an elephant, in a state which illustrates very well the mode of its dentition and that of the mammoth. In the jaws are seen teeth much worn, and behind them, in cavities formed within the bone itself, the next set of molares; the teeth in actual use at the time of the animal's death, appear to have been, from the number of the laminæ of enamel, the second set of molares; and as these fall out at about the age of six years, its age was probably between four and five years.

with a sort of canal. In this particular it resembles both the elephant and the morse which have a similar structure of the lower jaw. In the mammoth, however, it is shorter and more obtuse than in the elephant.

The posterior angle of the jaw is obtuse, but still distinct and prominent, and is not nearly so much rounded as in the elephant. The condyle, which is the most characteristic part, approaches more nearly in its form to that of the elephant, and resembles it very closely, but the coronoid process is higher. These parts are all of them widely diverse in their structure from those of any carnivorous animals, and would alone be sufficient to indicate that the mammoth could not have belonged to them.

The jaw which belongs to Mr Peale's skeleton is two feet and ten inches in length, and weighs sixty-three pounds; that of which a fragment is contained in the museum at Paris appears to have been somewhat smaller. In an elephant of eight feet in height, the length of the same part is about two feet and two inches.

3. The cranium so far as its anatomy is hitherto known, bears a general and pretty close resemblance to that of the elephant. The bones of the upper part of it, however, having never been discovered, no certain inferences can be drawn with regard to its size and shape except from analogical reasoning. There can be little doubt that the mammoth equalled the elephant in the enormous thickness of its cranium, since the same cause which requires this structure in the latter, would also require it in the former, viz. the necessity for an ample place of insertion for the muscles of the neck. That these must have been numerous and strong, appears from the great size and weight of the head, teeth, and tusks, which would require great strength and power to support them; and this is confirmed by the formation of the vertebræ of the neck themselves, which are adapted to give insertion to such muscles.

The situation of the molares of the upper jaw, their relation to the roof of the mouth, and the structure of the roof of the mouth, bear a resemblance to the same circumstances in the hog and hippopotamus, thus adding another to the many indications of a correspondence, in some of their characteristics and habits, between these animals and the mammoth.

4. The structure of the lower jaw, even before the discovery of the upper, indicated, from its resemblance to the elephant and morse, that the animal to which it belonged had possessed tusks. The discovery of sockets in the upper

jaw, into which they had been inserted, placed it beyond doubt that the tusks which had been found at the same time and in the same places with the grinders, &c. also belonged to the same animal.

They are implanted in the os incisivum as in the elephant. They consist of an ivory, a section of which presents lines forming curvilinear lozenges, and are, according to Cuvier, almost impossible to be distinguished from those of the elephant. Mr Peale believes that the section of the tusk of the elephant presents always oval lines, and that of the mammoth circular; and that they may be distinguished from one another by this circumstance; also that the mammoth tusk is composed of strata of two different substances; the inner having the texture of ivory though less hard, whilst the outer is more dense and firm, and acts as an envelope or sort of enamel to the other. Cuvier asserts, on the other hand, that the lines shown in a section of elephant's tusk are often circular, and those of mammoth's elliptical, and that the elephant's, like the mammoth's, has an envelope of a substance different from its internal part.

The degree of curvature in the tusk varies; in some instances being but slight, in others approaching almost to the semicircular form. That which was found with the Philadelphia skeleton has a very great curvature, and is of great size. It measures ten feet and seven inches along the bend. Its point is not altogether in the same direction with its base, but exhibits some tendency to the spiral form. The sockets in which they were placed are about eight inches deep, and about six inches apart; but their direction is much more oblique than in the elephant—for although thus near to each other at their base, the extremities are more than eight feet asunder. There has been some doubt as to the mode in which they should be implanted in their sockets, whether with the concavity looking upwards as in the elephant, or downwards as in the morse. It has been thought that with so great a curve, a disposition like that of the elephant would render these instruments perfectly useless, whereas, if bent downward, they might serve for digging in the earth, tearing up herbs and roots, &c.; but the analogy of the elephant and the probability that the semicircular form was a rare occurrence, render it more likely that they were disposed like those of the elephant.

5. The vertebræ of the neck in the mammoth are nine in number; they are short, and of course must have given to the animal but a short neck. The spinous processes of those

nearest to the head are long, but they do not continue, as you descend the spinal column, of so uniform a length in proportion, as the elephant, a circumstance which indicates a less strong back in the mammoth. The vertebræ of the back are nineteen, with a corresponding number of ribs. The ribs are smaller where they are connected with the cartilages, and larger towards the vertebræ than in the elephant. The six first pair are very large and strong; the remainder, particularly the last few pair, very short and small; a circumstance, which together with a narrow and shallow pelvis, indicate a smaller abdomen and less voluminous intestines than in the elephant.

6. The anterior extremities in their general structure resemble those of the elephant. The scapula of Mr Peale's skeleton measures about three feet in extreme length, the humerus two feet ten inches, and the radius about two feet five inches. The diameter of the long bones of the anterior extremities is greater than that of those of the posterior; and the difference is greater than in the elephant. The radius is to the humerus,

| | |
|---|---|
| In the mammoth as | 6 : 7 |
| In the elephant as | 6 : 8 |

The scapula is to the humerus,

| | |
|---|---|
| In the mammoth as | 9 : 8 |
| In the elephant as | 6.5 : 8 |

That is, in the former the scapula is one-ninth longer, and in the latter one-fifth shorter than the humerus; a difference which would have no inconsiderable effect upon the proportion which the height of these animals would bear to their general size and bulk; since, other circumstances being the same, the scapula of the mammoth would be about one-third longer than that of the elephant. Of the accuracy of these results there is the less doubt, since the bones of the extremities were found together, and probably therefore belonged all to the same individual.

7. The femur was the first observed and described of all the bones of the mammoth and its length, but particularly its great thickness, produced a strong impression with regard to the bulk of the animal to which it belonged. The length of one of these bones as given by Cuvier, is three feet and between seven and eight inches; the diameter of the head of the bone about seven inches and a half, its greatest diameter between the head and trochanter where the form is not circular, one foot and six inches, at the lower end one foot, and in the middle seven inches and a half. The length of

the femur, according to Mr Peale, is three feet seven inches, and that of the tibia, two feet, making the length of the tibia to that of the femur nearly as 6 to 10, a proportion about the same as in the elephant. The measurement of another tibia contained in the museum of Camper is given by Cuvier, the length of which is 0.71 of the French metre, or equivalent to about two feet and five inches; a femur bearing the same proportion to this, as those of which the length is stated above, would give a length of not less than four feet four inches and a half.

The hind feet are very much smaller than the fore feet, but not more so than in the elephant. The structure of the two first phalanges of the toes in the fore feet, is such as to indicate a greater freedom of motion in the extreme phalanx, than is possessed by the elephant, and in this respect they approach nearer to a resemblance with the structure of the hippopotamus.

8. The actual size of the mammoth is calculated by Cuvier, from the dimensions of the different bones which have been given. The sum of the tibia and femur added together, makes the length of the posterior extremities five feet and seven inches; that of the radius and humerus makes the anterior extremities five feet and three inches. The length then of the anterior extremities to that of the posterior would be in the ratio of 1.7 to 1.8 very nearly. The measurement of an elephant of eight feet in height, gives four feet nine inches for the anterior and five feet for the posterior extremity, which affords almost precisely the same ratio of 1.7 : 1.8. Upon the supposition then, that the two animals had very nearly the same relative proportions throughout, it might be concluded that as the elephant with a posterior extremity of five feet has a total height of eight feet, that the mammoth with a posterior extremity of five feet and seven inches would have a total height of about nine feet. But it must be recollected that the scapula of the mammoth is nearly one-third of its own length longer than that of the elephant, which must increase the height of the mammoth one foot, i. e. to ten feet. Mr Peale has given a height of eleven feet to his skeleton*; but in the opinion of Cuvier and of Sir

* The dimensions of this skeleton, as given by Mr Rembrandt Peale, in the Historical Disquisition on the Mammoth, are as follows:

| | FT. | IN. |
|---|---|---|
| Height over the shoulders | 11 | 0 |
| ,, at the hips | 9 | 0 |

Everard Home, he has placed the scapulas too low, and has not properly arranged the joints, the necessary effect of which would be to increase the height, particularly of the fore part of the body, above its natural standard.

The skeleton collected by Mr Peale, upon the measurement of which this opinion is founded, is not smaller than the average of the bones which have been discovered. Ten feet may be considered then as probably the fair average height of the mammoth, which is far less than was believed on the first discovery of these bones and from the inspection of separate, insulated specimens. There is no ground, according to Cuvier, for the opinion that the mammoth ever attained the height of twelve feet, far less surpassed it*.

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| | FT. | IN. |
|---|---|---|
| Length from the chin to the rump | 15 | 0 |
| ,, from the point of the tusks to the end of the tail, | | |
| ,, following the curve | 31 | 0 |
| ,, in a straight line | 17 | 6 |
| Width of the hips and body | 5 | 8 |
| Length of the under jaw | 2 | 10 |
| (Weight of the same 63 1-2lbs.) | | |
| Length of the thigh bone | 3 | 7 |
| Smallest circumference of ditto | 1 | 6 |
| Length of the tibia | 2 | 0 |
| ,, of the humerus | 2 | 10 |
| Largest circumference of ditto | 3 | 2½ |
| Smallest ditto ditto | 1 | 5 |
| Length of the radius | 2 | 5½ |
| Circumference at the elbow | 3 | 8 |
| Length of the scapula | 3 | 1 |
| ,, of the largest vertebra | 2 | 3 |
| ,, of the sternum | 4 | 0 |
| ,, of the tusks | 10 | 7 |
| Circumference of one of the molares | 1 | 6½ |
| Weight of ditto 4lbs. 10oz. | | |
| ,, of the whole skeleton 1000lbs. | | |

Of the bones found and described by Bishop Madison in 1811, the

| | | |
|---|---|---|
| Length of the pelvis from sacrum to pubis was | 1 | 5 |
| ,, from side to side | 1 | 4½ |
| ,, femur, almost | 3 | 0 |
| Circumference of ditto | 1 | 5 |

One part of a tusk measured three feet one inch in length and two feet in circumference at its base; when entire it was probably five feet and a half long. Largest tooth weighed seven pounds and a quarter—smallest three or four. These must have been the remains of a smaller animal than Mr Peale's.

* The largest bone of which I have found any account is the tibia mentioned on p. 400, said by Cuvier to measure 0.71 French metre, or about two feet and five inches; a femur to correspond to this must have measured at least four feet four and a half inches, giving six feet nine inches for the posterior and six feet four and a half inches for the anterior

The mammoth then surpassed the elephant but little in height; in length, however, it must have considerably exceeded it. The skeleton of Mr Peale is fifteen feet long from the extremity of the nose to the posterior part of the ischium. The elephant of ten feet does not go beyond eleven feet. There must have been likewise a great diffe-

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extremities. Following the method of calculation employed in the text, we get, for the total height of the body to which these extremities belonged, about twelve feet, on the supposition that the animal to which Mr Peale's skeleton belonged was only of ten feet; but if his really were of eleven feet, as he supposed, the individual to which we refer must have attained the height of about thirteen feet and a half. There are, however, so many inaccurate reports of the sizes, &c. of these bones, and so much uncertainty in our modes of calculation, that after all we cannot place entire dependence on results derived from them. Were credit to be given to Dr Mather's account of a thigh-bone seventeen feet long, the animal to which it belonged must have been nearly fifty feet high. Still there can be but little doubt that the above calculations form as near an approximation to the truth, as we are capable of, in the present state of knowledge.

The strange opinions which have formerly been entertained with regard to the nature and size of the mammoth, have proceeded either from the ignorance and love of the marvellous of the vulgar, or from erroneous modes of judging adopted by the learned. The real stature of the mammoth, as now ascertained, is far below what was supposed on the first discovery of its bones, by even scientific men. They proceeded, in forming their estimate, upon the supposition that the mouth of the animal contained, at the same time, all the sorts of teeth which had been discovered, in each jaw; this would truly give an enormous bulk to the whole. "La forme quarreè de ces enormes dents machelieres prouve qu'elles etoient en nombre dans la machoire de l'animal; et quand on n'y en supposeroit que six au meme quatre de chaque côtè, on peut juger de l'enormitè d'une tetè qui auroit seize dents machelieres pesant chacune dix ou onze livres. Enc. Method. Hist. Nat. Tom I.

It is stated as an article of intelligence in a French periodical work (Mag. Encyclop. Vol. 68. p. 171) in the year 1807, that a person at Baltimore had announced the discovery of an immense reservoir on the Missouri, a quarter of a mile square in extent, filled six feet deep with enormous bones; and that he offered, for a sufficient compensation, to procure a complete skeleton, fifty-four feet long, and twenty-two high, with eight enormous teeth in each jaw. The journalist gravely suggests that there is probably some exaggeration about this account!

Not much more probable is the account which is given in Muller's Recueil des Voyages au Nord, of the belief of the inhabitants of the countries where the Siberian elephant's remains are found; they supposed that he lived and died under the earth, and had the power of enlarging and contracting his body at pleasure, so as to move with facility, but was sometimes seen above ground. "This animal", says Muller, "is four or five yards high and about thirty feet long. His colour is greyish. His head is very long, and his front very broad; on each side, precisely under the eyes, there are two horns, which he can move and cross at pleasure."

A still more preposterous belief of ancient times was, that these fossil bones were the bones of the fallen angels, who were thought to have lived and perished on our earth.

rence in the bulk of the limbs and of the body in general. Every thing about the skeleton indicates this. The long bones of the extremities particularly, are larger in diameter in proportion to their length; a circumstance which clearly points at a greater quantity of muscle, &c. about the limbs, and a greater weight in the body to be supported and moved by them.

In forming an opinion of the probable form of the soft parts of this animal, we must be governed by the analogy of those which resemble it the most nearly in its bones, and by the indications which can be collected with regard to its food, residence, and habits of life. Several circumstances have been pointed out which approximate the mammoth to the hog and hippopotamus. Where it departs from the elephant it approaches them. This is the case with regard to the grinders, the roof of the mouth, and the structure and size of the ribs and pelvis, which indicate a less voluminous intestinal canal. They of course indicate also a departure from the diet of the elephant to one more easily digested, that is to a diet like that of the hog and hippopotamus, which consists of roots, grain, succulent herbs, and aquatic plants.

Standing therefore in this relation to these animals as it regards its food, it must be inferred, that in the structure of the parts about its mouth, it probably also bore some considerable resemblance to them; that it possessed either the snout of the hog, the thick, strong and projecting lips of the hippopotamus, or the trunk of the elephant. There are many reasons for believing that it was endowed with such an organ as the latter. The weight of the head of the mammoth, from its large bones and teeth and its projecting tusks, was very great; hence its neck was made short; the anterior extremities are, as has been seen, very high; and this would prevent the animal from being able with its mouth to reach the ground. But even did not these circumstances prevent, the tusks would alone form a sufficient obstacle. Were the animal aquatic, these considerations would not be conclusive, but as the structure of the feet forbids such a supposition, they render it almost certain that the mammoth must have had a trunk, some instrument resembling it, or else some extraordinary formation of the snout and lips, of which we have, among animals at present existing, no example.

Finally then, the mammoth was probably an animal nearly resembling the elephant in most of its external characteristics; of about the same height, but of greater comparative

length; more bulky in the general proportions of its body, but with a smaller abdomen; having projecting tusks and a long trunk, which might bear a greater or less resemblance in detail to that of the elephant, and feeding partly upon leaves and herbs, partly on fruit, grain, roots, &c. These inferences are all that the premises will allow us to make; but we may rely upon these with considerable confidence, as being in general a near approach to the truth.

Many fossil bones and teeth have been discovered in various parts of the world, belonging to no existing species of animal, and bearing a general resemblance to those of the mammoth, but still not exactly resembling them. The teeth particularly possess the same generic character, but differ in the shape and arrangement of the conical eminences on the surface of the crown. Bones of this sort have been found in France, in various parts of Italy, in Peru, in Paraguay, &c. &c. Cuvier after a careful comparison of these bones makes them out to have belonged to four different species, so, that including the animal which has been described, the genus to which he gives the systematic appellation MASTODON, includes five species, all fossil and extinct as follows*:—

1. *Great Mastodon*—Mammoth of the Ohio.

2. *Mastodon with narrow grinders*—about one third smaller than the preceding species. Its remains have been dug up at several places in Europe and America.

3. *Little Mastodon with narrow grinders*—similar to the last, but still smaller, found in Saxony and other parts of Europe.

4. *Mastodon of the Cordilleras*—discovered by Humboldt in South America; it is distinguished by its large square teeth, and must have equalled in size the great mastodon.

5. *Mastodon of Humboldt*—the smallest species of the genus, with teeth like the preceding; also discovered by Humboldt in South America.

In situations similar to those in which these bones have been found, others have been discovered in various parts of the world belonging to six other extinct species of pachydermatous animals, viz, 1 rhinoceros, 2 hippopotami, 2 tapirs, and 1 elephant. From the facts connected with the situation, &c. of these bones, Cuvier draws the following general results.

* Annales de Mus. vol. 8, p. 401.

These bones are found every where sunk in beds of nearly similar character, and are mingled with those of animals at present existing. The beds are always alluvial, are near the surface, and are commonly of a marly or sandy nature. The bones themselves are generally accompanied by the remains of marine animals; but some are without these remains, while others are surrounded by the shells of fresh water testacea.

It is probable that these bones were covered by the last or nearly the last catastrophe which has produced a revolution upon the surface of the globe; that this catastrophe was an inundation; but as there is no proof that the sea remained for any length of time or in a quiet state, over these bones, it must have been temporary; and there are indications also that it did not reach to the tops of high mountains, nor even so as to overflow the high valleys of America. The bones are not worn as if they had been long exposed to the rolling motion of the waves, but they are separated from one another and frequently broken in pieces. It is probable that they were not carried to any considerable distance by the motions of the flood; but that the animals to which they belonged, lived for the most part in the parts of the world where their remains are now found. If this be true, it will of course follow, that the frozen regions of the north were formerly inhabited by animals of genera that are now confined to the torrid zone, such as the elephant, rhinoceros, and hippopotamus*.

This suggests a question of some interest and no small difficulty. Was the climate of the countries where these animals lived and died, similar, at the time of the catastrophe which destroyed them, to the climate in which their congeners now live; or was it then as it is now, cold, and were the animals constituted and covered so differently from those of the torrid regions as to enable them to exist in it? In favour of the latter supposition, it may be argued, that the anatomical differences between the elephant and rhinoceros of Siberia, and those at present existing within the tropics, are as great as exist between many other animals that inhabit the extremes of heat and cold, and that are enabled to exist, simply by means of superior thickness and warmth of covering; and that this was the case with these is rendered probable by the discovery of the carcasses of the elephant

* Annales de Mus. Tom 8 ut supra.

and rhinoceros in the ice of Tungusia, both covered with long hair and wool. On the other hand, as is remarked by Professor Buckland, we find the remains not only of animals but of vegetables, which are now peculiar to the torrid zone, in the cold regions, for whose existence in them we cannot account. Besides, on what food can we suppose that herbivorous animals could have subsisted during the long polar winters. They could hardly be supposed all to migrate south; and admitting they could feed on branches of trees, where were these to be found in countries that scarcely produce a tree, and where the moss and lichens, almost the only vegetable productions, are covered under the snow? And yet in these countries where there would seem to have been such a scarcity of food, the bones are found in almost incredible quantities; whole islands are formed of them at the mouth of the Lena, and they are discovered encased in icebergs of enormous size, from which they are constantly disengaged by the heat of the sun. We can as yet form no certain conclusions on this subject.

## General Intelligence.

*New Periodical work.*—The Lyceum of Natural History of New York have lately published the first number of their "Annals". Its contents are valuable, and evince the ardour of the members of this highly respectable institution, in regard to the natural history of our country. The object of the work is to give publicity to the papers read before the Lyceum; "the preference to be given in all cases to such as tend to elucidate the knowledge of the natural productions of our own country". We understand it is contemplated to publish from four to six numbers in the course of the next twelve months, at from 25 to 37½ cents, or perhaps 50 cents each, the price depending in a great measure on the number of plates in each number. The price of the first number is 25 cents; it contains four papers, two of which are on botany, one on mineralogy, and one on "a new species of Cephalopterus", by Dr Mitchell, President of the Society.

*Rieussec's Chronograph for noting small intervals of time.*—This instrument has the form and size of a large pocket

chronometer. The dial-plate is moveable on an axis passing through its centre. The dial makes a revolution in a minute, and each of its divisions corresponds to a second of time. When the observer wishes to mark the precise instant when any phenomenon takes place, he presses a button, and a small pin or metallic point, traversing the summit of a cone filled with printers' ink, and placed opposite the fixed zero of the moveable dial, marks on the circumference, divided into seconds, a very fine point, which indicates the second, or fraction of a second, which corresponds to the beginning and end of the interval of time which it is wished to measure. The instantaneous contact of the point has no influence on the motion of the dial, and the firmness of the point enables us to estimate the fourth part of the divisions of the dial-plate.—[*Bib. Univers.*]

*New apparatus for describing curves.*—An ingenious apparatus has been invented in England by Mr J. Jopling for generating curves. It is represented as peculiarly simple, and manageable, and free from any thing to obstruct the operator from seeing the describing point. It is expected to be a valuable acquisition to shipwrights, architects, engravers, and others, "as it describes all species of conchoidal, elliptic, cardioidal, and many other species of curves; every section of a ship so that they shall range; arches of every form that can be desired; and it may be successfully applied to describe an immense variety of patterns, which you can make perfectly symmetrical, identical, or vary in any manner." In the September number of Tilloch's Philosophical Magazine is a certificate of the merits of this apparatus, signed by Professor Gregory, Mr Aikin, Mr Tredgold, &c. The apparatus may be had at Mr T. Jones', Charing-Cross, London.

*Test for Proto-salts of iron.*—Professor Ficinus, of Dresden, strongly recommends a solution of muriate of gold, as the most delicate of all tests for the presence of protoxide of iron in solution, surpassing considerably even the gall nut. It requires the presence of carbonate of soda, which in some analyses, may perhaps interfere with its use. A grain of green vitriol, with an equal weight of soda, dissolved in four pints of water, produces, with a drop of solution of muriate of gold, a strong precipitate, which gradually assumes a purple colour. Without the soda, the effect did not appear in less than three days. M. Ficinus thinks the process may be improved even to the determination of the quality of protoxide of iron present.—[*Bib. Univers.*]

*Remarkable Meteor.*—May 23d, at 10 o'clock at night a luminous meteor was observed at Kiel in Denmark. It was seen almost at the same time at Copenhagen, which is sixty miles from Kiel. This will give some idea of its size and velocity, which was apparently not very great. At Kiel it seemed to take a direction from south-east to north-east, and to have an elevation of 30°. It was visible for 10 seconds. As it disappeared, it threw out a volume of sparks, and left a luminous track in the sky.—[*Philos. Mag. Sept.* 1823.]

*New facts respecting the atmosphere.*—Professor Zimmerman, of Giessen, has announced that he has ascertained that all atmospheric aqueous substances, as dew, snow, rain, and hail, contain meteoric iron combined with nickel. Rain also usually contains salt, and a new organic substance composed of hydrogen, oxygen, and carbon, to which he has given the name of *pysine.*—[*Philos. Mag.*]

*Acid earth of Persia.*—Lieut. Col. Wright of the royal engineers, who lately came over land from India, brought a small quantity of this natural production from Persia. The natives apply it to the same uses that lemons and limes are used for elsewhere, namely, to make their sherbets, of which considerable quantities are used, they being prohibited the use of wine. The acid earth is found in great quantities at a village called Daulakie, in the south of Persia, between three and four days' journey from Bushire on the Persian Gulf.

Some analytical experiments made on a few grains of it by W. H. Pepys, Esq. gave the following results.—About one-fifth is soluble, by trituration, in boiling distilled water. The solution changes litmus paper and solution of cabbage red. It yields copious precipitates with nitrate and with muriate of barytes—indicating the presence of sulphuric acid. The triple prussiate gave a strong blue precipitate; and the sulphuret of ammonia a copious blackish brown precipitate—proofs of the presence of iron. The solution, when evaporated nearly to dryness, yielded crystals, which by their figure and taste seemed to be acidulous sulphate of iron. The earthy matter was not examined,—the principal aim of the experiments being only to ascertain the nature of the free acid in a product so abundant, where it is found, that it might be taken up in cart-loads.—[*Philos. Mag.*]

*New work on Geology.*—Dr Webster has nearly ready for publication, Elements of Geology, to be illustrated by numerous diagrams, sections, &c.

## Art. XLVI.—*Biographical Memoir of Count* Claude Louis Berthollet*. [*Edin. Phil. Jour.*]

The name of M. Berthollet has been long known in every part of Europe, and cannot fail to occupy a high place among the distinguished chemists of the nineteenth century. He was born at Taloire in Savoy, on the 9th December, 1748, and, like his distinguished colleague M. La Grange, he was an Italian by birth as well as by education. After having taken his degree of Doctor of Medicine at the University of Turin, he went to Paris, where he carried on the medical profession with so much success, that he was nominated one of the Physicians of the Duke of Orleans, the uncle of the reigning Sovereign. Notwithstanding the excellence of this appointment, he seems to have devoted the greatest part of his time to the study of Chemistry, which soon became his exclusive occupation.

The brilliant discoveries which had been made by Black, Priestley, Scheele, and Cavendish, formed the elements of that grand revolution in chemistry, which was completed under the direction of Lavoisier. In this great work the French chemist was associated with Fourcroy and Berthollet, the one distinguished by his eloquence and his powers of illustration, and the other by his sagacity and his experimental acquirements. As the limits of this notice will not permit us to analyse the various memoirs which Berthollet communicated to the Academy of Sciences and to the National Institute, we shall content ourselves with a general view of the discoveries which they contain.

One of the earliest and most important subjects to which Berthollet directed his attention, was the analysis of Ammonia, the nature and the proportion of the elements of which he determined with a degree of accuracy which later researches have scarcely been able to improve. He resolved the pure gas into its elements, by making it pass very slowly along an ignited porcelain tube, of a small diameter,—a method which has been more recently practised by Gay-Lussac. In finding ammonia in the products of animal

* For some of the facts in this hasty and imperfect sketch, we have been indebted to a short life of Count Berthollet, by M. Auger.



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substances, he was led to consider the presence of azote in organised bodies as the distinctive character of animality, and thus to make an important step in animal chemistry. This valuable memoir was published among those of the Academy of Sciences for 1785*.

The observations which Scheele had published on the prussic acid, and its different combinations, though in every respect fine and interesting, were yet insulated and incomplete. M. Berthollet resumed the subject with peculiar success, and recognised in it a compound acid, in which oxygen did not exist. The next researches of our author related to the combinations of sulphur with hydrogen; and though the new views which arose out of this inquiry met with considerable opposition, yet they were soon universally adopted.

One of the most important discoveries by which M. Berthollet is distinguished, is that of the application of the oxymuriatic acid to the purposes of bleaching. This acid was discovered by Scheele, but its properties were made known principally by the labours of our author. The application of this acid to the purposes of bleaching was discovered by Berthollet about the year 1786. Some of his experiments, of which he made no secret†, were exhibited to our late distinguished countryman Mr Watt, who immediately saw the importance of the discovery, and some time afterwards actually applied it in whitening 500 pieces of cloth. In the beginning of the year 1788, some foreigners attempted to obtain in England a monopoly of this valuable process, but their application for a patent was resisted by Mr Watt, and by Mr Cooper, and the late Mr Henry of Manchester; and the two last of these gentlemen formed the first establishments in which this great discovery was first applied on a large scale. The great improvements in this process, which were subsequently made by our country-

* In consequence of Sir Humphrey Davy having stated it as his opinion, that oxygen was one of the constituents of ammonia, A. B. Berthollet, our author's only son, afterwards analysed this gas, and confirmed the results previously obtained by his father. M. Berthollet sen. had found its composition to be 72.5 hydrogen, and 27.5 azote, whereas his son found the oxygen to be 75.5, and the azote 24.5. The memoir of M. Berthollet jun. was read to the Institute on the 24th March, 1808.

† The only advantage which Berthollet derived from this great discovery, was a present of a bale of cotton-stuffs bleached by his process, which was sent to him by an English manufacturer. This fact is stated by M. Auger. It is probable that they were sent by Mr Watt.

man Mr Tennant of Glasgow, in combining the oxymuriatic acid with lime, and in forming a portable bleaching salt, by uniting the gas with dry quicklime, have increased the value, and widely extended the utility of Berthollet's discovery.

The combinations of the oxymuriatic acid with the alkalies, though equally interesting in a scientific point of view, have not yet found the same useful applications. The experiments of Berthollet on the oxide of ammoniacal gold, made us better acquainted with this dreadful compound, though its effects are still less frightful than those of the fulminating silver, which he discovered soon after, and which explodes violently, even by the percussion occasioned by a drop of water falling upon it.

In the examination of these compounds, our author seems to have been led to those experiments, by which he has conferred on the art of dyeing as great a benefit as that which he rendered to the kindred art of bleaching. Hitherto that branch of the useful arts consisted of the most absurd receipts, and was founded upon the most ridiculous theories. Hellot, Macqueer, Bancroft, and Bergman had indeed begun to renovate the art of dyeing. Mr Keir and Mr Bancroft appear to have been the first who suggested the true theory of mordants; but it is to Berthollet undoubtedly that the complete establishment of the theory belongs.

Upon the death of Macqueer, Berthollet succeeded him in the situation of superintendant of the arts connected with chemistry, and so zealously did he devote himself to the objects of this office, that almost all the papers which he inserted in the "*Memoirs of the Academy*," in the "*Journal de Physique*," and in the "*Annales de Chimie*," relate principally to the promotion of the chemical arts. In the year 1791, he published his "*Elemens de l'art de Teinturier*," in one vol. 8vo.; and a second edition of it, greatly improved and enlarged, was published in 1814, in 2 vols. 4to. This treatise has always been regarded as a standard work, and, along with the practical processes of the art, it contains the clearest theoretical views of the principles upon which these processes depend.

In the year 1776, M. Berthollet published a separate work, entitled "*Observations sur l'Air.*" In 1780, when he was only thirty-two years of age, he was admitted a member of the Academy of Sciences. In 1789 he published a work under the title of "*Precis d'une Theorie sur la Na-*

*ture de l'Acier, sur ses Preparations,*" &c. In 1792, he was named one of the Commissioners of the Mint. In 1794 he was appointed a member of the Commission of Agriculture and the Arts; and, about the same time, he was chosen Professor of Chemistry at the Polytechnic School, and also at the Normal School. At the establishment of the Institute in 1795, he held a prominent place in the list of this learned body; and, in the same year, he published his "*Description de Blanchissement des Toiles.*"

In consequence of the subjugation of Italy by the French arms, Berthollet and Monge were appointed deputies by the Directory, to select those objects of the arts and sciences which ought to be transferred to Paris. In the execution of this task, General Bonaparte became acquainted with their zeal and knowledge; and such was the high opinion which he formed of them, that he induced them to accompany him, in 1798, in his unfortunate expedition to Egypt. In that country they distinguished themselves by their zeal in relieving the wants of the French army, and by their activity as the leading members of the Institute which Bonaparte had established at Cairo.

Upon their return to France, in 1799, with Bonaparte, they were both honoured by the First Consul with the rank of members of the Conservative Senate, and each of them was afterwards provided with a senatorerie.

When the French throne was re-occupied by its legitimate Sovereign in 1814, Louis XVIII. appointed Berthollet a member of the Chamber of Peers; and, from attachment, no doubt, to the Bourbon Family, he took no part in the Chamber which Bonaparte had organised, after his return from Elba.

A short time after he returned from Egypt, M. Berthollet took up his residence at Arcueil, a village about three miles south of Paris, where he pursued, in peaceful seclusion, those fine researches which adorned the close of his philosophical career. The results of these labours were given in his "*Recherches sur les Lois de l'Affinité,*" which appeared in 1801, and in his "*Essai de Statique Chimique,*" which was published in 1803, in 2 vols. 8vo*.

* Besides the works now mentioned, Berthollet translated "*Kirwan's Essay on Phlogiston,*" and added notes, in which he controverted the opinions of the English chemist. He was the author also of a preliminary dissertation and notes, which accompanied Riffault's translation of "*Dr Thomson's System of Chemistry,*" which appeared at Paris in 1808.

While our author was thus extending the boundaries of chemistry, by his own immediate labours, his rank in society, and his means of liberality, enabled him to become an active patron of scientific men. At the village of Arcueil, distinguished as the residence of that illustrious individual the Marquis Laplace, Berthollet established, in 1806, the *Society of Arcueil*, which met in his own house, where he formed a cabinet of physical instruments for the use of its members. This Society consisted of the Marquis Laplace, Count Berthollet, M. Biot, M. Humboldt, M. Thenard, M. Decandolle, M. Collet-Descostils, A. B. Berthollet, and Malus. They have published three volumes of their Memoirs, entitled "*Mémoires de Physique et de Chimie de la Société d'Arcueil*," the first of which appeared in 1807, the second in 1809, and the third in 1817. At the meetings of this Society, which took place every fifteen days, new and interesting experiments were repeated, memoirs upon different subjects were read by the members, and each of them was charged with the perusal of several journals or works, connected with the particular science which he cultivated, and the report upon these works was communicated to the Society. "Celui qui a conçu," says Berthollet himself, "le projet de former cette reunion, y trouve, en voyant approcher la fin de sa carriere, la douce satisfaction de contribuer par cette pensée, aux progres des Sciences auxquelles il s'est devoué, beaucoup plus efficacement qu'il n'auroit pu le faire par les travaux qu'il peut encore se promettre de continuer."

This interesting association, kept together for a while by the amiable character, and the eminent talents of its founder, seems to have speedily declined, and probably owed its declension to that dreadful event, which deprived Berthollet of his only son, and the association of one of its most eminent members. The death of A. B. Berthollet, by his own hands, could not fail to throw a shade over an institution so closely associated with his afflicted family. The writer of this hasty sketch had the high satisfaction of meeting with Count Berthollet, at the country-house of his friend and neighbour the Marquis Laplace at Arcueil, and will never forget the intelligence and benignity of this interesting man. The late celebrated Mr Watt, with whom he kept up a constant intercourse, entertained for him the purest friendship, and we have often listened with delight to the sentiments of respect and affection which he always expressed for the French chemist.

At the advanced age of seventy-four, this eminent man suffered much from a number of boils, followed by an abscess of uncommon magnitude, which occasioned great suffering. A fever, however, which ensued, carried him off, after three days continuance, on the 6th November 1822, the same year in which the Sciences were deprived of Herschel, Haüy, and Delambre. M. Berthollet left behind him an aged widow, who had devoted her life to ensure the happiness and tranquillity of her husband.

Although M. Berthollet had dedicated his life to science, yet he had a great taste for literature, and, like his friend Mr Watt, he perused the principal literary works of the day. From his early life he had a great passion for theatrical amusements, which continued to afford him pleasure, even in his latest years. M. Berthollet was a member of most of the scientific institutions of Europe, who were proud to enrol such a name in the list of their members. We look forward, with high expectations, to the memoir of his life, which may soon be expected from the eloquent pen of Baron Cuvier.

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Art. XLVII.—*An Account of the Fire of St Elmo.* (*Extracted from a Paper in the Ed. Phil. Jour.*)

In the month of June 1808, passing from the Island of Ivica to that of Majorca, on board a Spanish polacca ship, fitted as a cartel, and manned by about thirty ruffians, Genoese, Valencians, and Catalonians; a fine southerly gale, by seven in the evening, brought us within 6 or 7 leagues of the anchorage in Palma Bay. About this time, the sea-breeze failing us astern, was shortly succeeded by light and baffling breezes off the land. No sooner had the setting sun withdrawn his golden beams from the tops of the lofty hills, which rise to the westward of the town, than a thick and impenetrable cloud, gathering upon the summit of Mount Galatzo, spread gradual darkness on the hills below, and extended at length a premature obscurity along the very surface of the shore. About nine, the ship becalmed, the darkness was intense, and rendered still more sensible by

the yellow fire that gleamed upon the horizon to the south, and aggravated by the deep-toned thunder which rolled at intervals on the mountain, accompanied by the quick rapidity of that forked lightning, whose eccentric course, and dire effects, set all description at defiance. By half-past nine, the hands were sent aloft to furl top-gallant-sails, and reef the top-sails, in preparation for the threatening storm. When retiring to rest, a sudden cry of St Elmo and St Ann, was heard from those aloft, and fore and aft the deck. An interpreter called lustily down the hatchway, that St Elmo was on board, and desired me to come up. A few steps were sufficient, and, to my great surprise, I found the top-sail-yards deserted, the sails loose, and beating in the inconstant breeze, the awe-struck and religious mariners, bare-headed, on their knees, with hands uplifted, in voice and attitude of prayer, in earnest and muttering devotion to St Elmo or St Ann, according to the provincial nature of their speech.

On observing the appearance of the masts, the main-top-gallant-mast-head, from the truck, for three feet down, was perfectly enveloped in a cold blaze of pale phosphorous-looking light, completely embracing the circumference of the mast, and attended with a flitting or creeping motion, as exemplified experimentally by the application of common phosphorus upon a board; and the fore and mizen top-gallant-mast-heads exhibited a similar appearance in a relative degree.

This curious illumination continued with undiminished intensity for the space of eight or ten minutes, when, becoming gradually fainter and less extensive, it finally disappeared, after a duration of not less than half-an-hour.

The seamen, in the mean time, having finished their devotions, and observing the lights to remain stationary, returned promptly to the yards, and, under favour of this "Spirit of the Storm," now quickly performed that duty, which, on a critical conjuncture, had been abandoned, under the influence of their superstition and their fears. During the prevalence of the lights, as well as through the remaining hours of night, the wind continued, except in occasional puffs, light and variable; and the morning ushered in with a clear sky, a hot sun, and a light southerly breeze, which, in due time, brought us safe to the anchorage of Palma.

Conversing with the interpreter on the nature of this extraordinary atmospherical phenomenon, he expressed his

implicit belief that it was provided by the immediate power of St Elmo, the tutelar deity of "those who travel on the vasty deep," in regard to their interests in a moment of sudden danger; and used every argument to persuade me, that the present safety of the ship was due to the very timeous and friendly interference of this aerial demigod; and that no accident could possibly have happened to the sails, while the seamen were at prayers, as long as the light glowed stationary on the mast. Had the light, he continued, descended gradually from the mast-head to the deck, and from thence to the kelson, as he had often seen it, the event would have prognosticated a gale of wind or other disaster, and, according to the depth of the descent, so would be the nature of the evil to come. In the present instance, the lights gradually disappeared, like the snuff of a candle, and the weather continued clear and fine for several subsequent days.

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ART. XLVIII.—*Reflections on Volcanos.* By M. GAY-LUSSAC. *Read before the Royal Academy of Sciences at Paris, May* 19, 1823*. [*Lon. Phil. Mag.*]

BEFORE I offer to the public the following observations on volcanos, a subject which has so long presented a wide field for hypothesis and conjecture, I ought to premise that I am not in possession of all the knowledge necessary for its full discussion, and that I shall only take a brief and partial view of it, confining myself to certain questions upon which chemistry may throw some light, and which do not absolutely demand an acquaintance with geology. The subject is however one of considerable difficulty, and one which gives me a claim on the indulgence of my readers.

Two hypotheses may be formed as to the cause which produces volcanic phenomena. According to one of these, the earth remains in a state of incandescence at a certain depth below the surface (a supposition strongly favoured by

* *Ann. de Chimie et de Phys.* tom. xxii. p. 415.

the observations which have been recently made on the progressive increase of temperature in mines); and this heat is the chief agent in volcanic phænomena. According to the second hypothesis, the principal cause of these phænomena is a very strong and as yet unneutralized affinity existing between certain substances, and capable of being called into action by fortuitous contact, producing a degree of heat sufficient to fuse the lavas and to raise them to the surface of the earth by means of the pressure of elastic fluids.

According to either of these hypotheses, it is absolutely necessary that the volcanic furnaces should be fed by substances originally foreign to them, and which have been some how or other introduced into them.

In fact, at those remote epochs which witnessed the great catastrophes of our globe,—epochs at which the temperature of the earth must have been higher than it now is, the melted substances which it contained consequently more liquid, the resistance of its surface less, and the pressure exercised by elastic fluids greater,—all that could be produced was produced; an equilibrium must have established itself, the agitated mass must have subsided into a state of repose which could no longer be troubled by intestine causes, and which can only now be disturbed by fresh contact between bodies accidentally brought together, and which were, perhaps, only added to the mass of the globe subsequently to the solidification of its surface.

Now the possibility of contact between bodies in the interior of the earth, the ascent of lava to a considerable height above its surface, ejections by explosion, and earthquakes, necessarily imply that those extraneous substances which penetrate into volcanic furnaces must be elastic fluids, or rather liquids capable of producing elastic fluids, either by means of heat which converts them into vapour, or by affinity which sets at liberty some gaseous elements. According to analogy, the only two substances capable of penetrating into the volcanic furnaces in volumes sufficiently large to feed them, are air, and water, or the two together. Many geologists have assigned to the air an important office in volcanos; its oxygen, according to them, sustains their combustion: but a very simple observation will suffice to overthrow this opinion entirely.

How, indeed, is it possible for the air to penetrate into the volcanic furnaces when there exists a pressure acting from within towards the exterior, capable of raising liquid lava, a

body three times as heavy as water, to the height of more than 1000 *mètres*, as at Vesuvius, or even of more than 3000, as is the case in a great number of Volcanos? A pressure of 1000 *mètres* of lava, equivalent to a pressure of 3000 *mètres* of water, or to that of about three hundred atmospheres, necessarily excludes the introduction of any air whatever into volcanos; and as this pressure subsists for a long series of years, during which the volcanic phænomena continue in the utmost activity, it follows that the air can have no share whatever in their production.

It is moreover evident, that if the air had a free communication with the volcanic furnaces, the ascent of lava, and earthquakes, would be impossible.

If the air cannot be the cause of volcanic phænomena, it is probable, on the contrary, that water is a very important agent in them.

It can hardly be doubted that water does penetrate into volcanic furnaces. A great eruption is invariably followed by the escape of an enormous quantity of aqueous vapour, which, being condensed by the cold which prevails above the summits of volcanos, falls again in abundant rains accompanied by terrific thunder, as was the case at the famous eruption of Vesuvius in 1794, which destroyed Torre del Greco. Aqueous vapours and hydrochloric gas have also frequently been observed in the daily ejections of volcanos. It is scarcely possible to conceive the formation of these in the interior of volcanos without the agency of water.

If we admit that water is one of the principal agents in volcanos, we must proceed to examine the real means by which it acts, upon either of the hypotheses we have just laid down concerning the heat of volcanic furnaces. If we suppose, according to the first hypothesis, that the earth continues in a state of incandescence, at a certain depth below its surface, it is impossible to conceive the existence of water at that depth; for the temperature of the earth having formerly been of necessity higher, its fluidity greater, and the thickness of its solid crust less than at the present time, the water must necessarily have disengaged itself from its interior and have risen to the surface.

If we wish therefore to give any air of probability to this hypothesis, and to maintain the importance of water as a principal agent in volcanos, we must assume that it penetrated from the surface downwards to the incandescent strata of the earth; but in order to come to this conclusion,

we must suppose that it had a free communication with those strata, that it gradually acquired heat before it reached them, and that the vapour it produced compressed by the weight of its whole liquid column, obtained a sufficient elastic force to elevate the lavas, to produce earthquakes, and to cause all the other terrible phænomena of volcanos.

The difficulties obviously involved in these suppositions, and to which many others might be added, render the hypothesis that the heat of volcanos is to be attributed to the state of incandescence of the earth at a certain depth below the surface perfectly inadmissible. I must further remark that this incandescence is itself quite hypothetical; and that, notwithstanding the observations on the increase of temperature in mines, I regard it as extremely doubtful.

Upon the second hypothesis which we laid down, that the principal cause of volcanic phænomena is a very strong and as yet unneutralized affinity existing between certain substances, and capable of being called into action by fortuitous contact, it is necessary to suppose that the water meets, in the interior of the earth, substances with which it has an affinity so strong as to effect its decomposition and to disengage a considerable quantity of heat.

Now the lavas ejected by volcanos are essentially composed of silica, alumina, lime, soda, and oxide of iron;—bodies which, being all oxides and incapable of acting upon water, cannot be supposed to have originally existed in their present state in volcanos; and from the knowledge which has been obtained of the true nature of these substances, by the admirable discoveries of Sir Humphrey Davy, it is probable that the greater part, if not all of them may exist in a metallic state. There is no difficulty in conceiving that by their contact with water they might decompose it, become changed into lava, and produce sufficient heat to account for the greater part of the volcanic phænomena. But as my object is not to construct a system, but, on the contrary, to examine the probability of the two hypotheses under consideration, and to direct the attention of future observers towards those facts which are most likely to throw light upon the causes of volcanos, I shall proceed to point out the consequences which must result from the adoption of the latter hypothesis. If water be really the agent which sustains the volcanic fires by means of its oxygen, we must admit, as a necessary and very important consequence, that an enormous

quantity of hydrogen, either free or combined with some other principle, would be disengaged through the craters of volcanos. Nevertheless it does not appear that the disengagement of hydrogen is very frequent in volcanos. Although, during my residence at Naples in 1805, with my friends M. Alexander de Humboldt and M. Leopold de Buch, I witnessed frequent explosions of Vesuvius, which threw up melted lava to the height of more than 200 *mètres*, I never perceived any inflammation of hydrogen. Every explosion was followed by columns (*tourbillons*) of a thick and black smoke, which must have been ignited if they had been composed of hydrogen, being traversed by bodies heated to a temperature higher than was necessary to cause their inflammation.

This smoke, the evident cause of the explosions, contained therefore other fluids than hydrogen. But what was its true nature? If we admit that it is water which furnishes oxygen to volcanos, it will follow that, as its hydrogen does not disengage itself in a free state, it must enter into some combination. It cannot enter into any compound inflammable by means of heat at its contact with the air; it is however very possible that it unites with chlorine to form hydrochloric acid.

A great many observations have in fact been recently given to the world on the presence of this acid in the vapours of Vesuvius; and, according to that excellent observer M. Breislack, it is at least as abundant in them as sulphurous acid. M. Menard de la Groye (whose conclusions on volcanos I however think too precipitate to be adopted), and M. Monticelli to whom the public is indebted for some excellent observations on Vesuvius, also regard the presence of hydrochloric acid in its vapours as incontestable. I have myself no longer any doubt on this fact, though during my stay in the neighbourhood of Vesuvius I could never distinguish by the smell any thing but sulphurous acid; it is, however, very possible that the extraneous substances mixed with the hydrochloric acid disguised its odour.

It is very much to be wished that M. Monticelli, who is so favourably situated for observing Mount Vesuvius, would place some water, containing a little potass, in open vessels on different parts of this volcano; the water would gradually become charged with acid vapours, and after some time it would be easy to determine their nature.

If the whole of the hydrogen furnished by water to the combustible substances contained in volcanic furnaces becomes combined with chlorine, the quantity of hydrochloric acid disengaged by volcanos ought to be enormous. It would then become a matter of surprise that the existence of this acid had not been observed sooner. Besides, the chlorine must enter into combination with the metals of silica, alumina, lime, and oxide of iron; and in order to explain the high temperature of volcanos, we must suppose that the contact of the chlorides of silicium and aluminium with water produces a great evolution of heat. Such a supposition is by no means improbable; but even if we admit it, we are still in want of a great many data, before we can render its application to volcanic phænomena satisfactory.

If the combustible metals are not in the state of chlorides, hydrochloric acid is then a secondary result; it must proceed from the action of the water upon some chloride (probably that of sodium), an action which is favoured by the mutual affinity of oxides. M. Thenard and I have already shown that if perfectly dry sea-salt and sand are both heated red hot, no hydrochloric acid is evolved: we found also that sea-salt undergoes no alteration from the agency of water alone; but if aqueous vapour is suffered to pass over a mixture of sand or of clay with sea-salt, hydrochloric acid is immediately disengaged in great abundance.

Now the production of this acid by the conjoint action of water and some oxide upon a chloride, must be very frequent in volcanos. Lava contains chlorides, since it gives them out abundantly when it comes in contact with the air. MM. Monticelli and Covelli extracted, merely by repeated washings with boiling water, more than nine per cent of sea-salt from the lava of Vesuvius in 1822. It is exhaled through the mouths of volcanos; for very beautiful crystals of it are found in the scoriæ covering incandescent lava. If, therefore, lava comes in contact with water, either in the interior of the volcano, or at the surface of the earth by means of air, hydrochloric acid must necessarily be produced. Messrs. Monticelli and Covelli have in fact observed the production of acid vapours in crevices nearly incandescent; but they took them for sulphurous acid. I am, on the contrary, convinced that they were essentially composed of hydrochloric acid. It is allowable to doubt the accuracy of their observation, since they have expressed considerable uncertainty as to the nature of these acid vapours, whether they were sulphurous or muriatic.

It is well known that lava, especially when it is spongy, contains a great deal of specular iron. In 1805, on inspecting, with M. de Humboldt and M. de Buch, a gallery formed on Vesuvius by the lava of the preceding year, which after encrusting the surface had gradually sunk below it, I saw so great a quantity of specular iron, that it formed what I may be allowed to call a vein: its beautiful micaceous crystals covered the walls of this gallery, in which the temperature was still too high to permit us to stay long. Now the peroxide of iron being in a high degree fixed at a temperature much higher than that of lava, it is not probable that it was volatilized in that state: it is very probable that it was primitively in the state of chloride.

If, indeed, we take protochloride of iron which has been melted, and expose it to a dull red heat in a glass tube, and then pass over its surface a current of steam, we shall obtain a great quantity of hydrochloric acid and of hydrogen gas; and black deutoxide of iron will remain in the tube. If, instead of steam, we use dry oxygen, we shall obtain chlorine and peroxide of iron. This experiment is easily made by mixing chloride of iron with dry chlorate of potass; at a very moderate temperature chlorine disengages itself in abundance. If we suffer a stream of moist air to pass over the chloride at the temperature above mentioned, approaching to a red heat, we obtain chlorine, hydrochloric acid, and peroxide of iron. The effects observed with perchloride of iron are the same. If it be exposed to moisture, hydrochloric acid is immediately obtained, or chlorine if it be exposed to oxygen; in either case peroxide of iron is formed.

I can imagine, therefore, that iron in the state of chloride exists in the smoke exhaled by volcanos, or by their lava at its contact with the air, and that by means of heat, of water, and of the oxygen of the air, it is changed into peroxide, which collects, and assumes a crystalline form during precipitation. If we suffer a stream of chlorine at the temperature of about 400° to pass over a steel harpsichord-wire, the wire immediately becomes incandescent, but not nearly so soon as with oxygen. The perchloride of iron is very volatile; it crystallizes on cooling into very small light flakes, which instantly fall into deliquescence on exposure to the air. It heats so strongly with water, that I should not be surprised, if, in a large mass, and with a proportional quantity of water, it should become incandescent. I

make this observation in order to suggest to my readers, that if silicium and aluminium really existed in the bowels of the earth in the state of chloride, they might produce a much higher temperature upon coming in contact with water, since their affinity for oxygen is much greater than that of iron.

If, as can hardly be doubted, sulphurous acid be really disengaged from volcanos, it is very difficult to form an opinion of its true origin. Whence should it derive the oxygen necessary to its formation, unless it be the result of the decomposition of some sulphates by the action of heat; and of the affinity of their bases for other bodies? This opinion appears to me to be the most probable; for I cannot conceive, from what is known of the properties of sulphur, that it is an agent in volcanic fires.

Klaproth and M. Vauquelin have conjectured that the colour of basalt might be ascribed to carbon; but, to confute this supposition, we need only remark, that when a fusible mineral, even if it contain less than ten hundredths of oxide of iron, is heated to a high temperature in a crucible made of clay and pounded charcoal (*creuset brasque*), a considerable quantity of iron is produced, as Klaproth has shown in the first volume of his Essays. Messrs Gueniveau and Berthier assert, moreover, that there remains no more than from three to four hundredths of oxide of iron in the scoriæ of highly heated furnaces. Now, as lava contains a large proportion of iron, and as the basalt which has been analysed contains from fifteen to twenty-five hundredths of the same substance, it is not probable that carbon could exist in the presence of so large a quantity of iron without reducing it*.

Is it not possible that if hydrogen be disengaged from volcanos, metallic iron, the oxides of which have the property of reducing at a high temperature, may be found in lava? It is at least certain that it does not contain iron in the state of peroxide; for lava acts powerfully on a magnetized bar, and the iron it contains appears to be at the precise degree of oxidation which alone is determinable by water; that is to say, in the state of deutoxide. I have already shown, that if hydrogen be mixed with many times its vol-

* When these reflections were read before the Academy of Sciences, M. Vauquelin observed that he had found carbon in the ashes ejected by the last eruption of Vesuvius.—*Ann. de Chim.* tom. xxiii. p. 195.

ume of aqueous vapour, it becomes incapable of reducing oxides of iron.

The necessity which appears to me to exist for the agency of water in volcanic furnaces, the presence of some hundred parts of soda in lava, as also of sea-salt and of several other chlorides, renders it very probable that it is sea-water which most commonly penetrates into them. One objection, however, which I ought not to conceal, presents itself: namely, that it appears necessarily to follow from this supposition, that the streams of lava would escape through the same channels which had served to convey the water, since they would experience a slighter resistance in them than in those through which they are raised to the surface of the earth. It might also be expected that the elastic fluids formed in volcanic furnaces before the ascent of lava to the surface of the earth, would frequently boil up through those same channels to the surface of the sea. I am not aware that such a phænomenon has ever been observed, though it is very probable that the *mophètes*, so common in volcanic countries, are produced by these elastic fluids.

On the other hand, we may remark that the long intervals between the eruptions and the state of repose in which volcanos remain for a great number of years, seem to demonstrate that their fires become extinguished, or at least considerably deadened; the water would then penetrate gradually by its own pressure into imperceptible fissures to a great depth in the interior of the earth, and would accumulate in the vast cavities it contains. The volcanic fires would afterwards gradually revive, and the lava, after having obstructed the channels through which the water penetrated, would rise to its accustomed vent; the diameter of which must continually increase by the fusion of its coats. These are mere conjectures; but the fact is certain, that water does really exist in volcanic furnaces.

It is evident that the science of volcanos is as yet involved in much uncertainty. Although there are strong grounds for the belief that the earth contains substances in a high degree combustible, we are still in want of those precise observations which might enable us to appreciate their agency in volcanic phænomena. For this purpose an accurate knowledge of the nature of the vapours exhaled by different volcanos is requisite; for the cause which keeps them in activity being certainly the same in each, the products common to all might lead to its discovery. All other products will be accidental; that is to say, they will be the result of

the action of heat upon the inert bodies in the neighbourhood of the volcanic furnace.

The great number of burning volcanos spread over the surface of the earth, and the still greater number of mineral masses which bear evident marks of their ancient volcanic origin, ought to make us regard the ultimate or outermost stratum of the earth as a crust of scoriæ, beneath which exist a great many furnaces, some of which are extinguished, while others are rekindled. It is well calculated to excite surprise that the earth, which has endured through so many ages, should still preserve an intestine force sufficient to heave up mountains, overturn cities, and agitate its whole mass.

The greater number of mountains, when they arose from the heart of the earth, must have left these vast cavities, which would remain empty unless filled by water. I think, however, that De Luc and many other geologists have reasoned very erroneously on these cavities, which they imagine stretching out into long galleries, by means of which earthquakes are communicated to a distance.

An earthquake, as Dr Young has very justly observed, is analogous to a vibration of the air. It is a very strong sonorous undulation, excited in the solid mass of the earth by some commotion which communicates itself with the same rapidity with which sound travels. The astonishing considerations in this great and terrible phænomenon are, the immense extent to which it is felt, the ravages it produces, and the potency of the cause to which it must be attributed. But sufficient attention has not been paid to the ease with which all the particles of a solid mass are agitated. The shock produced by the head of a pin at one end of a long beam causes a vibration through all its fibres, and is distinctly transmitted to an attentive ear at the other end. The motion of a carriage on the pavement shakes vast edifices, and communicates itself through considerable masses, as in the deep quarries under Paris. Is it therefore so astonishing that a violent commotion in the bowels of the earth should make it tremble in a radius of many hundreds of leagues? In conformity with the law of the transmission of motion in elastic bodies, the extreme stratum, finding no other strata to which to transmit its motion, makes an effort to detach itself from the agitated mass, in the same manner as in a row of billiard balls, the first of which is struck in the direction of contact, the last alone detaches itself and receives

the motion. This is the idea I have formed of the effects of earthquakes on the surface of the globe; and I should explain their great diversity, by also taking into consideration, with M. de Humboldt, the nature of the soil and the solutions of continuity which it may contain.

In a word, earthquakes are only the propagation of a commotion through the mass of the earth, and are so far from depending on subterranean cavities, that their extent would be greater in proportion as the earth was more homogeneous.

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Art. XLIX.—*On the native country of the Wild Potato, with an Account of its Culture in the Garden of the Horticultural Society; and Observations on the Importance of obtaining improved Varieties of the cultivated Plant.* By Joseph Sabine, Esq. F. R. S. &c. [*Horticult. Trans.*]

The possession of the plants of the *Native Wild Potato* has been long a desideratum, and from the great importance and extensive use of the cultivated root, the subject, of course, became an object of attention to the Horticultural Society. In my communications with the Society's correspondents on the other side of the Atlantic, this was pointed out as one of the most interesting objects to which their attention could be directed; and it is with no small satisfaction, that I am able to state that our inquiries have been successful.

Great doubts have existed as to what parts of the new world the natural habitat of the Solanum tuberosum, or Potato, should be assigned; and the question is even now a matter of discussion among Botanists of the greatest eminence. The vegetable, in its cultivated state, was first known in this country, as the Potato of Virginia; I conceive, however, there can be little doubt that the plants which Sir Walter Raleigh found in that colony, and transferred to Ireland, had been previously introduced there, from some of the Spanish territories, in the more southern parts of that quar-

ter of the globe; for had the potato been a native of any district, now forming part of the United States, it would before this time have been found and recognised by the botannical collectors who have traversed and examined those countries.

From the Baron de Humboldt's observations on the potato in Mexico*, it seems certain that it is not wild in the south-western part of North America; nor is it known otherwise than as a garden plant, in any of the West India islands. Its existence, therefore, remains to be fixed in South America, and it seems satisfactorily proved, that it is to be found both in elevated places in the tropical regions, and in the more temperate districts on the western coasts of the southern part of that division of the new world.

According to Molina†, it grows wild abundantly in the fields of Chili, and in its natural state is called by the natives *maglia*, producing, when uncultivated, small and bitter tubers. The Baron de Humboldt asserts‡, that it is not indigenous in Peru, nor on any part of the Cordilleras, situated under the tropics. But this statement is contradicted by Mr Lambert§, on the authority of Don Jose Pavon and of Don Francisco Zea; the former of whom says, that he and his companions, Dombey and Ruiz, had not only gathered the Solanum tuberosum wild in Chili, but also in Peru, in the environs of Lima; and the latter has assured Mr Lambert, that he had found it growing in the forests, near Santa Fé de Bogota. The above account of Pavon is further confirmed by the evidence of a specimen gathered by him in Peru, and now forming a part of the herbarium of Mr Lambert, with the name of "Patatas del Peru."

Mr Lambert, in his communication to the *Journal of Science and the Arts*, which I have referred to, supposes that the wild potato is to be found on the eastern, as well as the western and northern sides of South America. His opinion on this point, appears to have been founded on the following circumstances:

Among the specimens in the herbarium formed by Commerson, when he accompanied Bougainville in his voyage

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* *Political Essay on the Kingdom of New Spain* Black's Edition, vol. ii. page 484.

† His. Nat. *du Chili*, p. 102.

‡ *Political Essay on the Kingdom of New Spain.* Black's Ed. vol. ii. p. 489.

§ *Journal of Science and the Arts*, vol. x. page 25.

round the world, is one of a Solanum, gathered near Monte Video. In the *Supplement to the Encyclopédie*, (vol. iii. p. 746,) this specimen was described, on the authority of M. Dunal, of Montpelier, as belonging to a species distinct from Solanum tuberosum, under the name of Solanum Commersonii, and it was subsequently published by M. Dunal, with the same name in the *Supplement* to his *Solanorum Synopsis**. (The article from the Encyclopédie is given below†.) Mr Lambert, however, conjectured this specimen to be that of the type of the cultivated potato, and was induced to do so, by information received from Mr Baldwin, an American botanist, that he had found the Solanum tuberosum wild, both at Monte Video, and in the vicinity of Maldonado, as well as from Captain Bowles, who had resided a considerable time at Buenos Ayres, and who had told him that this plant was a common weed in the gardens and neighbourhood of Monte Video.

The above statements certainly confirm the existence of a plant in sufficient abundance, near the shores of the Rio de la Plata, which Mr Lambert identifies with Commerson's specimen; but the proof that it is the Solanum tuberosum, in opposition to the decision of Mr Dunal, rests only on the opinion of Dr Baldwin, and Captain Bowles, without the usual satisfactory evidence of specimens, which have not been supplied by either of these gentlemen.

In order to elucidate the question as much as possible, I applied to M. Desfontaines, Director of the Museum of Natural History, in the Jardin du Roi, at Paris, for permission to have a drawing made of Commerson's original specimen; which was deposited in the herbarium under his charge. With a liberality and kindness which I cannot too highly compliment, the entire specimen was without delay, transmitted to me. It has much the appearance of being in a dwarf or stunted state. The label affixed to it is thus de-

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* Page 5

† Morelle de Commerson. Solanum Commersonii. Solanum caul herbaceo, piloso; foliis pinnatis sublyratis, pilosis; floribus corymbosis, terminalibus; pedicellis articulatis. Dun. Suppl. Sol. MSS.

Toute la plante est converte de poils simples: elle a les plus grands rapports avec le Solanum tuberosum; elle en diffère 1°. par ses feuilles profondement pinnatifides comme celle de la Pomme de terre, mais dont les folioles sessiles ne sont pas alternativement inégales. 2°. par la foliole impaire, qui est très grande. 3°. par la corolle, qui est à cinq divisions non à cinq angles. La racine de cette plante est encore inconnue.

scribed: "Hispanis Tomates—flores sunt palliduli—de la plage du pied du morne de Monte Video en Mai, 1767." The size of the blossom is evidently larger than that of the S. tuberosum, under similar circumstances; the depth of the divisions of the flowers, and the larger proportional size of the terminal leaf, present striking differences from correspondent parts of the common potato. Very little hairiness is perceptible on the specimen, which, if it had been taken from a plant of S. tuberosum, would probably have been much more hairy, as it usually is when stunted. It is also somewhat singular that Commerson, who could not but know the S. tuberosum and its various names, should have affixed, that of "Tomates" to his specimen; this makes it almost certain that he did not consider it to be the potato. On these grounds I have ventured to hesitate in concurring in the opinion of Mr Lambert, that we have sufficient evidence of the growth of the wild potato in the neighbourhood of the Rio de la Plata. It possibly may be found there, but its existence in that part of America is not proved, since it seems tolerably certain that Commerson's plant is not it, and Mr Lambert does not suppose that the plants seen by his correspondent and friend, were different from Commerson's.

Early in the spring of the present year, Mr Caldcleugh, who had been some time resident at Rio Janeiro, in the situation of Secretary to the British Minister at that Court, where he had been indefatigable in his exertions to forward the objects of the Horticultural Society, returned to England, having previously taken a journey across the country, and visited the principal places on the western coasts of South America. Among many articles of curiosity which he brought with him were two tubers of the wild potato, which he sent to me with the following letter:

*Montague-Place, Portman-Square, Feb.* 24, 1823.

My Dear Sir,

It is with no small degree of pleasure that I am enabled to send you some specimens of the Solanum tuberosum, or native Wild Potato of South America.

It is found growing in considerable quantities in ravines in the immediate neighbourhood of Valparaiso, on the western side of South America, in lat. 34½ S. The leaves and flowers of the plant are similar in every respect, to those cultivated in England and elsewhere. It begins to flower in the month of October, the spring of that climate, and is not very

prolific. The roots are small and of a bitterish taste, some with red and others with yellowish skins. I am inclined to think that this plant grows on a large extent of the coast, for in the south of Chili it is found, and called by the natives, *Maglia*, but I cannot discover that it is employed to any purpose.

I am indebted for these specimens to an officer of His Majesty's ship Owen Glendower, who left the country some time after me.

I am, my dear sir, ever sincerely yours,

ALEXANDER CALDCLEUGH.

The two tubers were exhibited to the Society, and a drawing made of them before they were planted. Had there been a third, I should have been tempted to have satisfied myself as to the real flavour, which Mr Caldcleugh as well as Molina, describes as bitter. They were planted separately in small pots, and speedily vegetated; they grew rapidly, and were subsequently turned out into a border, at about two feet distance from each other, when they became very strong and luxuriant. The blossoms at first were but sparingly produced, but as the plants were earthed up they increased in vigour, and then bore flowers abundantly; but these were not succeeded by fruit. The flower was white, and differed in no respect from those varieties of the common potato which have white blossoms. The leaves were compared with specimens of several varieties of the cultivated potato, which, generally, were rather of a more rugose and uneven surface above, and with the veins stronger and more conspicuous below, but in other respects, there was no difference between them. The pinnulæ which grew on the sides of the petiole, between the pinnæ of the leaves, were few, not near so numerous as in some varieties of the cultivated potato; but in specimens of other varieties that were examined, their leaves were destitute of pinnulæ, so that the existence of these appendages does not appear to be so essential a characteristic as has been supposed, and as is stated in the *Supplement to the Encyclopédie*.

The earth with which the plants had been moulded up, had been applied in considerable quantity, so as to form a ridge, the sides of which were full two feet high; and about the month of August, runners from the roots and joints of the covered stems, protruded themselves towards the surface of the ridge, in great numbers, and when they reached the light, formed considerable stems, bearing leaves and blos-

seems, so that at length the two plants became one mass of many apparently different plants issuing from all sides of the ridge. The appearance of these runners in such quantities induced a doubt as to the identity of the plant with our common potato, which doubt was increased when it was ascertained, that so late as the month of August, no tubers had been formed by the roots. The runners were, however, no otherwise different from what are formed by the cultivated potato under ground, except that they were more vigorous, as well as more numerous.

The plants have recently been taken up, and all doubt respecting them is now removed; they are unquestionably the Solanum tuberosum. The principal stems, when extended, measured more than seven feet in length; the produce was most abundant, above six hundred tubers were gathered from the two plants; they are of various sizes, a few as large or larger than a pigeon's egg, others as small as the original ones, rather angular, but more globular than oblong; some are white, others marked with blotches of pale red or white. The flavour of them when boiled was exactly that of a young potato.

The compost used in moulding up the plants was very much saturated with manure, and to this circumstance I attribute the excessive luxuriance of the growth of the stems; had common garden mould been applied, they would not probably have grown so strong, and I suppose that whilst the plants were thus rapidly making stems and leaves, the formation of the tubers was delayed, for the production of these has been the work of the latter part of the season; they cannot be called fully ripe, nor have they attained the size which they probably might have done if they had been formed earlier.

They will, however, answer perfectly for the purpose of reproduction (or for seed as it is technically called,) and they are in sufficient plenty to be subjected to treatment similar to a common crop of potato. The result of another year's experience is necessary to enable us fully to observe on the merits and value of this new introduction; but the following changes already appear to have attended its subjection to cultivation; the produce is most abundant, the tubers have lost all the bitterness of flavour which is attributed to them in the natural state, and their size is increased remarkably; from all which circumstances I am disposed to infer, that the original cultivators of this vegeta-

ble did not exercise either much art or patience in the production of their garden potatoes.

The increased growth of the potato, not only in these kingdoms, but almost in every civilized part of the globe, has so added to its importance, that any information respecting it has become valuable; the subject of this communication may, therefore, not be without interest. With the exception of wheat and rice, it is now certainly the vegetable most employed as the food of man; and it is probable that the period is at no great distance, when its extensive use will even place it before those which have hitherto been considered the chief staples of life. The effect of the unlimited extent to which its cultivation may be carried, on the human race, must be a subject of deep interest to the political economist. The extension of population, will be as unbounded as the production of food, which is capable of being produced in very small space, and with great facility; and the increased number of inhabitants of the earth will necessarily induce changes, not only in the political systems, but in all the artificial relations of civilized life. How far such changes may conduce to, or increase the happiness of mankind, is very problematical; more especially when it is considered, that since the potato, when in cultivation, is very liable to injury from casualties of season, and that it is not at present known how to keep it in store for use beyond a few months, a general failure of the year's crop, whenever it shall have become the chief or sole support of a country, must inevitably lead to all the misery of famine, more dreadful in proportion to the numbers exposed to its ravages.

Under such circumstances, and with such a prospect, it is surely a paramount duty of those who have the means and power of attending to the subject, to exert themselves in selecting and obtaining varieties of potatos, not only with superior qualities in flavour and productiveness, but which shall be less subject to injury by changes of weather, when in growth, and which may possess the quality of keeping for a length of time, either in their natural state, or under the operation of artificial treatment. This is one of the objects to which the care and energies of the Horticultural Society ought to be directed. Under its auspices, and by its means, some new kinds have been brought into notice, but a wide field of exertion is still before it. With the potatos cultivated in South America at the present time we are very little acquainted; there is one especially which has been heard of, but which has not yet reached us, known at Lima as

the yellow or golden potato, and which is reported to be far superior in flavour to any now grown in Europe.

On the subject of the potato there is also a point of curiosity and much interest open to those who have leisure and opportunity of conducting the investigation. Several accounts of its introduction into Europe, and especially into Great Britain and Ireland, are before the public, differing from each other, and none exactly correct; the entire truth is probably to be extracted from the whole, and ought to be supported by references to the original authorities for the different facts. To these, in order to render the early history of the potato complete, an account of its original discovery and the observations made on it by the first and early visitors to the shores of South America, should be obtained; and this research would probably lead to a detection of the circumstances attending its first introduction into Virginia, which is at present involved in obscurity.

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Art. L.—*Account of the Explosion of a Steam-Boiler at Lochrin Distillery.* By Robert Stevenson, Esq. F. R. S. E. Civil Engineer. [*Ed. Phil. Jour.*]

The alarming accident which happened at Lochrin Distillery, by the explosion of a large steam-boiler on the high pressure principle, having created a very considerable sensation in the public mind, Mr Adie optician and I, visited the spot on the following day, and were kindly received by Mr Haig, the proprietor of the works, who freely communicated to us every information on the subject.

It would be foreign to the object of this notice, to enter into any detail regarding the extent of Lochrin Distillery; but I cannot omit observing how important its operations must be in a public point of view, especially to the agriculturalist, when it is considered, that, in the form of duties to Government alone, the proprietors sometimes pay *Fifteen thousand pounds Sterling a week*, for spirits distilled from grain. Every circumstance, therefore, connected with operations of such magnitude, becomes an object of general concern.

A proposition having been made for boiling the large stills of Lochrin by means of steam at a high pressure, to be conducted through pipes into these vessels, as more economical and convenient for the works, than the common furnaces,—an apparatus was manufactured by the workmen belonging to the distillery, in which no expense seems to have been spared for making the steam-boiler as complete and effective as possible. The boiler and its appurtenances began to work about the 21st of March; but had only been in operation about twelve days, when something connected with the mercurial-gauge for measuring the intensity or pressure of the steam, was observed to be out of order. Before the engineer could be got to examine and repair it, an explosion took place, attended by circumstances which indicate the sudden production of a force uncontrollably great.

The boiler measured no less than about 37 feet in length, 3 feet in breadth at the bottom, 2 feet immediately under the top, and about 4 feet in height; and the bottom, forming a semicircle, rose into the body of the boiler. Its cross-section was of a crescent form, a construction adopted with a view to the more ready and beneficial circulation of the heat of the furnace. The whole weight of the boiler is said to have been about 9 tons; of which the top and sides were estimated to weigh about 7 tons. This large proportion of 7 tons weight was torn from the bottom by the expansive force, and thrown up with such amazing impetus, that it dashed aside its arched covering of brick-work, penetrated the roof of the boiler-house, and, according to the estimate of those who witnessed the scene, rose into the atmosphere to the height of not less than 70 feet before it began to descend. On the south, the boiler-house was flanked by other buildings; while it was free on the north. Owing to this circumstance, the projected mass naturally received an inclination to the northward, and, describing an arch in its passage through the air, it alighted on the roof of the great mash-house of the distillery, situate at the distance of 150 feet from the boiler-house, and in its fall carried every thing before it. Even the floor of the mash-house was broken up, and one side of a large circular mashing-vat of cast-iron was crushed in pieces.

To illustrate the expansive force still farther, we may observe, that the boiler was constructed of malleable iron plates, three-eighths of an inch in thickness, and only 8 inches in breadth. With a view to bind and strengthen the cross-section of the boiler, it was set upon thirty-six bars of cast-

iron, measuring 6 inches in depth, by 2¼ inches in thickness, forming so many ties across the semicircular bottom. Notwithstanding these precautions, we see, that the top and sides of this ponderous vessel were wrested from its bottom; and, though weighing about 7 tons, as before noticed, were projected into the air about 70 feet, and fell at the distance of 150 feet. It also deserves our particular notice, that the bottom, though lifted with the top and sides at least to the height of 14 or 15 feet, was found deposited among the rubbish merely on the outside of the boiler-house; it was bent, however, from its regular semicircular form, into an angular figure in the reverse direction; the convex having now become the concave side.

These circumstances strikingly show the invincible power of the agents employed in such apparatus, and point out the responsibility which unavoidably attaches itself to the employment of steam at a high pressure, in a manufactory, where numerous individuals, and much valuable property, are at stake. In this case, the greatest anxiety certainly existed on the part of the proprietors, to have recourse to every proper precaution; yet an explosion took place, and two workmen who were in attendance on the boiler, lost their lives. One of the sufferers was found with his head cloven in two. The legs of the other man were severed from the body, and found in the boiler-house, while the body itself was discovered among the rubbish on the outside of the building. Among the surprising circumstances, however, which attended this disaster, it may be noticed, that comparatively little damage was done, though the premises are every where composed of inflammable matters, and crowded with people at work, all of whom escaped without injury, excepting the two unfortunate individuals mentioned.

The boiler, in the act of bursting, discharged a great quantity of steam in the air, part of which was condensed upon the upper walls of the adjoining buildings, which still appear as if they had been partially white-washed. A dreadful noise was also heard at a distance like a clap of thunder; though those engaged within the premises do not appear to have been much alarmed by the noise of the explosion. It may be added, that the tremor produced by the concussion was distinctly felt at the distance of a mile from the Distillery.

It is now, perhaps, impossible to ascertain with certainty how this accident happened; but it deserves to be remarked, that the sides and top of the boiler were torn from the

bottom horizontally, in the direction of one of the rows of rivet-holes, almost in as regular a manner as if the separation had been made with a sharp instrument. We cannot help thinking, that this boiler was pierced with a superabundance of rivet-holes. For the plates, which were only 8 inches in breadth, were made to overlap each other 4 inches, and then rivetted in such a manner, that over the whole surface of the boiler only bands or compartments of about 4 inches in breadth, were left without perforations. These holes being, at the same time, pierced only about one inch and a quarter apart; almost as much of the iron at the seams or joinings was, by this means, cut into rivet-holes as was left in an entire state. We may add, that if this boiler, which was made with materials of great strength, had been more judiciously put together; if fewer rivets had been employed, and if the bars across the bottom, had been rivetted and otherwise strongly connected with the horns or points of the crescent bottom, it might have resisted a much greater strain than it was calculated to sustain.

In building or constructing steam-boilers, the work should be so laid out by the artist, that the plates may *break joint*, if we may apply a technical term in masonry to this operation; or, in other words, the plates of which the boiler is to be formed should be so arranged, that the end-joint of one plate may fall into the middle of the two adjoining plates. If attention were paid to this arrangement, the plates of the top and bottom would form part of the sides, and the vessel would possess much additional strength, at the expense, perhaps of but a little more labour. In preserving the strength of the plates, great attention should also be paid to the punching or perforation of the holes in good order, that the seams may fit each other. The punch or chisel for this purpose, should be uniformly cylindrical, or have as little taper towards the point as possible; so that the fibre or texture of the iron may not be deranged in perforating the rivet-holes. When iron is unduly stretched in this operation, it produces an effect similar to what workmen term *cold-short;* and has a direct tendency to lessen the strength of the portions of iron remaining between the holes. These holes ought also, invariably, to be pierced, so as to run in a zig-zag or alternate direction, instead of being ranged in straight lines, as is sometimes done.

To show still farther the utility of these observations, let us suppose that a horizontal section of the boiler at Lochrin

contained 324 square inches of iron. After making every allowance for rivet-holes of the diameter of ⅞ths of an inch, perforated at the distance of about 1 inch and ⅛th apart, we find, from the aggregate strength of these portions of iron, supposing the whole to be in a sound state, and allowing at the rate of 27 tons as the force which a square inch of good iron will sustain, that the boiler would withstand a force of about 8748 tons, before it would be torn asunder. Instead of 1 inch and ⅛, let us suppose that the holes are perforated at the distance of 2 inches apart, and we shall then find that the boiler will sustain a force equal to about 12,724 tons, or equal to 3976 tons more. On examining the section of this boiler, it will be found, that its figure is not calculated to give strength, unless the *horns* or points of the crescent had been very strongly connected by bolts or rivets, to the bars crossing the arched bottom. For it is not sufficient to set a boiler upon cast-iron bars, and make them simply to embrace it by wedging with iron at the bottom, without fixing them with rivets, or bolts; neither does it appear that cast iron is so suitable for this purpose as malleable iron.

In explaining the immediate cause of the explosion, it has been supposed, that the upper ridge of the semicircular bottom of the boiler had been allowed to get into a state of incandescence, when a jet of water from the feeding-pipe having (as is imagined) been incautiously let into the boiler, the effect of an additional supply of water in this critical state of things, was to produce a sudden and great quantity of steam, or the extrication of gases of enormous volume, by the decomposition of the water, by which the boiler, as we learn, was projected into the air like a rocket.

In the first trials of the boiler at Lochrin, though weighing upwards of nine tons, it was found to vibrate and move in its place with the force of the steam at the rate of about 60 pounds to the square inch. The pressure was then, by the express orders of Messrs Haig, reduced to 40 pounds upon the square inch, and one of the safety-valves with this load, was put under lock and key, and the charge of it given to the foreman of the works. In consequence of some mismanagement, however, the pressure must obviously have been greatly increased. If we suppose the velocity of the top and sides of the boiler at the moment of the explosion, to have been at the rate of about 80 feet per second, its impetus in that case had been not less than about 720 tons. We here calculate the cast-iron bars in the usual way, though it must be recollected that this metal, when heated, loses

much of its strength. On the whole, however, it is probable that the entire impulse given by the explosive force, could not in this case have been less than 3380 tons on the area of the boiler, or about 215 pounds upon each square inch of its surface.

The working power of steam in the condensing engines upon Watt and Bolton's principle, is now usually adjusted to a pressure of from 2 to 5 pounds upon the square inch. But in Trevethick's or Woolf's high pressure engines, where there is no condensing apparatus, it is not unusual to work with upwards of 80 pounds on the square inch. The greatest precaution, therefore, in the application of this principle, becomes necessary in the management of the apparatus.

On the other hand, it may be proper to observe, that accidents like this of Lochrin, are by no means beyond the power of remedy. If proper attention were paid to the safety-valves, and to the obvious and simple indications of the mercurial gauge, and if the firemen were regular in supplying the boiler with fuel and water, the risk of explosion might with considerable certainty be avoided.

Notwithstanding the numerous improvements upon the steam-engine which are daily making, it is still a desideratum in the use of the steam-boiler to construct a safety-valve, which shall depend as little as possible upon the engine-men for the certainty of its operation. For this purpose, Mr Adie suggests, that a piece of plate-copper might be introduced into the main-hole of the boiler, the strength of which should be previously so adjusted that it shall give way when the expansive force of the steam exceeds about one-half more than the pressure at which it is intended to be wrought. For the greater safety of those near the boiler, a wooden or metallic pipe might be connected with this plate or regulator, which should be made to rise 12 or 14 feet above the boiler. Although this description of safety-valve would, perhaps, when occasionally thrown off, deprive us for a time of the use of the boiler; yet the object of the greater safety of persons in its neighbourhood would be attained.

Since the preceding part of this article was read before the Wernerian Society, the writer of it has again visited the scene of the explosion, in company with Mr Neill, secretary to that society, Mr Bald, engineer, and Mr Gutzmer, iron-founder and engine-maker; when the circumstances of this catastrophe were again inquired into, though without being

able to come to any very satisfactory result upon the immediate cause of the accident.

Upon inspecting the boiler, in order to ascertain if it had been heated to a state of incandescence, one end of the bottom bore marks of a brownish colour, such as iron generally exhibits when cooled from a state of redness, while, at the opposite extremity, ascertained to be the end of the boiler next to the furnace-door, part of a leaden plug, filling one of the rivet-holes, was found unmelted in its place. This leaden plug had been introduced with a view more effectually to guard against the very accident which we are now supposing to have happened, by the bottom of the boiler getting red-hot, and the introduction of a jet of water while it was in that state.

The circumstance of the leaden plug having been found unaltered in its place in the inside of the bottom of the boiler, seems to show that the part next to the furnace door had not been in a state of incandescence, otherwise this plug must have been melted in the interior, as it was either melted or had been broken off on the exterior side of the boiler, and disappeared. But it is possible that a quantity of water had remained in the boiler at the moment of the explosion, and that the current of air near the furnace door had been sufficient to prevent the inside part of the plug from melting. In a boiler 37 feet long, its bottom might be so distorted by the heat of the furnace, that a small quantity of water might remain at one end, while the other end was heated to redness; and this, on the introduction of water, would suddenly produce the extrication of gases sufficient, by their expansive force, to cause the explosion.

It is hardly possible to conceive that such violent and instantaneous effects could proceed from steam raised in the usual way, as there were two safety-valves in the top of the boiler, which were said to have been loaded with not more than 40 pounds to the square inch. It seems most probable, therefore, that the immediate cause of this accident, was the unduly heated state of the end of the boiler next to the feeding-pipe. This is also rendered likely, from the body of one of the unfortunate sufferers having been found near the position of this pipe after the accident, who is supposed to have been in the act of turning the cock when the explosion took place. It is, indeed, hardly possible upon any other hypothesis, to account for the production of a pressure of upwards of 200 pounds to the square inch, required for tearing

the boiler asunder, and projecting about two-thirds of it into the atmosphere to the height of 70 feet.

Still it must be allowed, that a considerable degree of uncertainty hangs over the cause of this explosion. If the valves were not strangely mismanaged, how is it possible that the steam could be raised gradually to such a pressure as was necessary to produce effects equal to the most violent results from the explosion of gunpowder? On the other hand, if we suppose that the end of the boiler next to the pipe for supplying it with water had got into a state of incandescence, and that the fireman had suddenly let a quantity of water into it, we can thus account for the extrication of gases capable of producing all the phenomena which followed. The boiler, in the first or experimental trials, had vibrated in its place with a pressure of 60 pounds to the square inch, as before noticed; but the valves were now loaded only with 40 pounds to the square inch. The probability therefore is, that at the moment of the explosion, the weakest part of the boiler had given way, before the safety-valves, comparatively small, when considered in reference to a boiler 37 feet in length, could operate for its relief, from the sudden and immense pressure applied. The safety-valves, indeed, appear to have performed their office, though they were inadequate to the intended purpose. One of them was thrown out to a great height, and described a large arch, in a direction somewhat different from that of the great mass of the boiler: this iron-valve, in its fall, passed through the roof of a distant house, one of the inmates of which narrowly escaped being killed.

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## Art. LI.—*Description of the Great Bandana Gallery, in the Turkey Red Factory of Messrs Monteith and Co. at Glasgow.* [*Jour. of the Roy. Ins.*]

The benefits of liberal-mindedness are nowhere more fully displayed than in the modern advancement of our chemical arts. A quarter of a century ago, manufacturing chemists were wont to shroud their operations in mysterious

secrecy, like the craftsmen of the dark ages, on a supposition, usually unfounded, of their being possessed of some wonder-working *recipes*, whose promulgation would be fatal to their interests. At that period, the monied proprietors of chemical factories were rarely practical chemists. They were, therefore, obliged to place entire dependence in certain operative adepts, whom they engaged at a considerable salary, to conduct their processes. These persons, having been previously employed as subordinate menials in some similar manufactory, had acquired a smattering notion of the routine of working: but, being entirely destitute of education, and having no general views concerning the business which they undertook to manage, they were perpetually falling into difficulties, and committing mistakes from time to time of the most ruinous description. Slight variations in the qualities and state of the materials employed, in the mode of mixture, in the temperature, or duration of the process, occasioned variations of result, which they could neither foresee, regulate, nor counteract; and, though the profits might be considerable on a successful operation, yet failures were so frequent and so expensive as to render the business not a little precarious and uncomfortable. Hence we can understand why chemical manufactories have undergone such vicissitudes of fortune,—some raising their proprietors to unexpected opulence, others sinking them to unlooked-for ruin.

The owners of chemical establishments, becoming at length impatient of the vassalage in which they had been long held by blundering and obstinate hirelings, began to inquire into the principles of their peculiar arts, and were thus led to cultivate the society of men of science. They now, for the first time, learned that economy and precision could be ensured to their processes, only by applying the same scientific rules which medical censorship, backed by the authority of law, had for a considerable time introduced with the happiest effect into the formerly mysterious and uncertain processes of pharmacy. Under this conviction, they consulted the chemical philosopher on their difficulties and disappointments. Suggestions, of greater or less value, were thus given and acted on, which led to new questions on the part of the manufacturer, and new researches on that of the chemist: and thus an alliance began between theory and practice, which has, in a very few years, carried several of the chemical arts of this country to an extraordinary pitch of perfection.

Instances have, undoubtedly, occurred of chemists of some reputation having given delusive advice to the manufacturer; as we see chemical authors publish, as processes of art, formulæ very disadvantageous and even absurd. These misdirections are almost always to be ascribed either to neglect of experimenting with due care on an adequate scale, or superficial acquaintance with the principles of the science. It is very possible for a person to compile a dazzling series of class experiments with grandiloquent explications, without being either a philosophical or a practical chemist.

The league between science and art, which has, in this country, been the slow growth of necessity, was long ago effected in France, to a considerable extent, by authority of the government. The illustrious minister, Colbert, fraught with the most enlightened views of state policy, founded a school of science to superintend and assist the dyeing manufactories of the kingdom. From that school, conducted as it has been by a succession of eminent philosophers, have emanated invaluable researches on the most beautiful, but, at the same time, most intricate, of all the chemical arts,—researches to which France owes much of her eminence in this very profitable branch of her national industry.

The manufactory of Messrs Monteith and Co. has been long celebrated in the commercial world for the excellence and beauty of its cotton fabrics. The madder-reds rival in brilliancy and solidity any ever produced at Adrianople; and the white figures, distributed over the cloth, surpass, in purity, elegance, and precision of outline, the original Bandana designs.

The opulent and enlightened proprietors have been careful to avail themselves of every resource which the latest improvements in chemistry and mechanics could supply. In this respect, their factory deserves to be studied as a school of practical science. The permission now granted of describing their discharging-gallery is a proof of their liberality, as well as of the confidence justly entertained, that the capital and skill, now engaged in their establishment, are better securities for the preference which their goods possess in the European market, than the utmost mystery in conducting their processes.

Hence they have rarely refused to strangers, respectable for their rank or science, permission to visit their manufactory, a favour which it is impossible to enjoy without being gratified and instructed.

Their new arrangement of hydrostatic presses was completed in 1818, under the direction of Mr George Ridger,

senior, manager of the works. It consists of sixteen of these engines beautifully constructed, placed in one range in subdivisions of four; the spaces between each set, serving as passages to admit the workmen readily to the back press. Each subdivision occupies twenty-five feet; whence the total length of the apparatus is one hundred feet.

To each press is attached a pair of patterns in lead, or *plates* as they are called, the manner of forming which will be described in the sequel. One of these plates is fixed to the upper block of the press, this block is so contrived that it turns on a kind of universal joint, which enables this plate to apply more exactly to the under plate. The latter rests on the moveable part of the press, commonly called the *sill*. When this is forced up, the two patterns close on each other very nicely, by means of guide-pins at the corners, fitted with the utmost care.

The power which impels this great hydrostatic range is placed in a separate apartment, called the machinery-room. This machinery consists of two cylinders of a peculiar construction, having cylindric pistons accurately fitted to them. To each of these cylinders three little force-pumps, worked by a steam-engine, are connected.

The piston of the large cylinder is eight inches in diameter, and is loaded with a top-weight of five tons. This piston can be made to rise about two feet through a leather stuffing or collar. The other cylinder has a piston of only one inch in diameter, which is also loaded with a top-weight of five tons. It is capable, like the other, of being raised two feet through its collar.

Supposing the pistons to be at their lowest point, four of the six small force-pumps are put in action by the steam-engine, two of them to raise the large piston, and two the little one. In a short time, so much water is injected into the cylinders, that the loaded pistons have arrived at their highest points. They are now ready for working the hydrostatic discharge-presses, the water pressure being conveyed from one apartment to the other, under-ground, through strong copper tubes of small calibre.

Two valves are attached to each press, one opening a communication between the large *prime-cylinder* and the cylinder of the press, the other between the small *prime-cylinder* and the press. The function of the first is simply to lift the under-block of the press into contact with the upper-block; that of the second is to give the requisite compression to the cloth. A third valve is attached to the press, for the purpose of discharging the water from its cylinder, when

the press is to be relaxed, in order to remove or draw through the cloth.

From twelve to fourteen pieces of cloth, previously dyed Turkey-red, are stretched over each other, as parallel as possible, by a particular machine. These parallel layers, are then rolled round a wooden cylinder, called by the workmen, a drum. This cylinder is now placed in its proper situation at the back of the press. A portion of the fourteen layers of cloth, equal to the area of the plates, is next drawn through between them, by hooks attached to the two corners of the webs. On opening the valve connected with the eight inch *prime-cylinder*, the water enters the cylinder of the press, and instantly lifts its lower-block, so as to apply the under-plate with its cloth, close to the upper one. This valve is then shut, and the other is opened. The pressure of five tons in the one inch *prime-cylinder*, is now brought to bear on the piston of the press, which is eight inches in diameter. The effective force here will, therefore, be 5 tons $\times 8^2 = 320$ tons; the areas of cylinders being to each other, as the squares of their respective diameters. The cloth is, therefore, condensed between the leaden pattern-plates, with a pressure of 320 tons.

The next step is, to admit the blanching or discharging liquor, (aqueous chlorine, obtained by adding sulphuric acid to solution of chloride of lime,) to the cloth. This liquor is contained in a large cistern, in an adjoining house, from which it is run at pleasure into small lead cisterns attached to the presses; which cisterns have graduated index tubes, for regulating the quantity of liquor according to the pattern of discharge. The stop-cocks on the pipes and cisterns containing this liquor, are all made of glass.

From the measure-cistern, the liquor is allowed to flow into the hollows in the upper lead-plate, whence it descends on the cloth, and percolates through it extracting in its passage, the Turkey-red dye. The liquor is finally conveyed into the waste-pipe, from a groove in the under-block. As soon as the chlorine liquor has passed through, water is admitted in a similar manner, to wash away the chlorine; otherwise on relaxing the pressure, the outline of the figure discharged, would become ragged. The passage of the discharged liquor, as well as of the water, through the cloth, is occasionally aided by a pneumatic apparatus, or blowing machine; consisting of a large gasometer, from which air, subjected to a moderate pressure, may be allowed to issue, and act in the direction of the liquids, in the folds of the

cloth. By an occasional twist of the air stop-cock, the workman also can ensure the equal distribution of the discharging liquor, over the whole excavations in the upper-plate. When the demand for goods is pressing, the air apparatus is much employed, as it enables the workman to double his product.

The time requisite for completing the discharging process in the first press, is sufficient to enable the other three workmen to put the remaining fifteen presses in play. The *discharger* proceeds now from press to press, admits the liqour, the air, and the water; and is followed at a proper interval by the assistants who relax the press, move forward another square of the cloth, and then restore the pressure. Whenever the sixteenth press has been liquored, &c., it is time to open the first press. In this routine, about ten minutes are employed; that is 224 handkerchiefs (16 × 14) are discharged in ten minutes. The whole cloth is drawn successively forward, to be successively treated in the above method.

When the cloth escapes from the press, it is passed between two rollers in front; from which it falls into a trough of water placed below. It is finally carried off to the washing and bleaching department, where the lustre of both the white and the red is considerably brightened.

By the above arrangement of presses, 1,600 pieces, consisting of 12 yards each = 19,200 yards, are converted into Bandanas in the space of ten hours, by the labour of four workmen.

The patterns, or plates, which are put into the presses to determine the white figures on the cloth, are made of lead, in the following way. A trellis frame of cast-iron, one inch thick, with turned-up edges, forming a trough rather larger than the intended lead pattern, is used as the solid groundwork. Into this trough, a lead plate about one-half inch thick, is firmly put by screw-nails passing up from below. To the edges of this lead plate, the borders of the piece of sheet-lead are soldered, which covers the whole outer surface of the iron frame. Thus a strong trough is formed one inch deep. The upright border gives at once great strength to the plate, and serves to confine the liquor. A thin sheet of lead is now laid on the thick lead-plate, in the manner of a veneer on toilette-tables, and is soldered to it, round the edges. Both sheets must be made very smooth beforehand, by hammering them on a smooth stone table, and then finishing with a plane: the surface of the thin sheet (now at-

tached,) is to be covered with drawing-paper pasted on, and upon this, the pattern is drawn. It is now ready for the cutter. The first thing which he does, is to fix down with brass pins, all the parts of the pattern, which are to be left solid. He now proceeds with the little tools, generally used by block-cutters, which are fitted to the different curvatures of the pattern, and he cuts perpendicularly quite through the thin sheet: the pieces thus detached are easily lifted out; and thus, the channels are formed, which design the white figures on the red cloth. At the bottom of the channels, a sufficient number of small perforations are made through the thicker sheet of lead, so that the discharging liquor may have free ingress and egress. Thus, one plate is finished; from which, an impression is to be taken by means of printer's ink, on the paper pasted on another plate. The impression is taken in the hydrostatic press. Each pair of plates constitutes a set, which may be put into the presses, and removed at pleasure.

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ART. LII.—*Account of Captain Scoresby's Magnetical Discoveries, and of his Magnetimeter and Chronometrical Compass.* [*Edin. Phil. Jour.*]

SEVERAL interesting and valuable papers by Captain Scoresby, respecting magnetism, having appeared in the Transactions of our learned Societies*, we propose to give a condensed account of the principal discoveries detailed in these papers, in order to bring into one point of view subjects of very considerable practical importance. In addition to the articles that are already before the public on this subject, we have had the opportunity of witnessing some of Mr Scoresby's experiments, and of examining his magnetical apparatus, and we are therefore enabled to communicate some particulars that have not hitherto been laid before the public.

Mr Scoresby's attention was first directed to the investigation of the magnetic laws, in consequence of a series of ex-

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* *Edinburgh Transactions*, vol. ix. p. 243, 353, and *Philosophical Transactions*, 1822, p. 241.

periments undertaken by him in the years 1815 and 1817, for determining the cause of the "deviation of the compass" on ship-board. In trying the magnetic properties of different masses of iron about the ship's deck, he found, what, indeed, was long before known to be the fact, that, in the high northern latitudes, all rods of iron, in a vertical position, were magnetical, while the same rods placed nearly horizontal, exerted little or no influence on the compass. The result of his inquiries into the law of the magnetic action was such as might have been expected, namely, that ferruginous substances became magnetical by position, the upper parts, as respects the plane of the magnetic equator intersecting them through the centre of gravity, acquiring south polarity, and the lower parts north polarity. But while this law seems universally to prevail, it exhibits an apparent modification by experiment, in the case of slender bars or thin plates of iron; for these bodies, when placed in the magnetic plane, exhibit no magnetic action on a compass; because the magnetic axis in them corresponding with their shortest axis, the two poles are so near together that they neutralize each other, with respect to their effects upon the compass.

As the magnetic plane may be readily discovered by experiment, with slender bars of iron free from permanent magnetism, Mr Scoresby constructed an instrument, called a *Magnetimeter**, with which the exact angle where the polarity of iron disappears may be determined; and this he finds gives him the complement of the dip, with such a degree of accuracy as in most respects to answer the ends of a dipping-needle.

In using this instrument for measuring small magnetic attractions, and enabling him to present a piece of iron to a compass at different times invariably at the same angle and distance, he could ascertain, if, by any treatment to which it might in the mean time have been subjected, any change whatever had taken place in its state as to magnetism. He then observed, that any kind of mechanical action upon a bar of iron, produced a change in its magnetical state, which, on being fully investigated, was found to follow a similar law as that of magnetism of position, with regard to the quality of the magnetism produced. Dr Gilbert, indeed, two hundred

* The Edinburgh Journal contains a plate and description of this machine. We have not copied them as they do not appear essential to the main facts developed by the experiments. [*Ed. B. Jour.*]

years ago, discovered that iron, when hammered in the magnetic meridian, became magnetical, in so far as, when made red-hot, and drawn out in this position, to be able to conform itself to the magnetic north and south, when floated by a piece of cork upon the water. But Mr S. went much farther. He ascertained, as it was reasonable to expect, that a horizontal position in the magnetic meridian was by no means the best position for the development of magnetism by percussion; but that the position of the dipping-needle, given to bars of iron, when hammered, produced the highest effect. A single blow with a hammer, on a bar of soft iron, held vertically, was found to be capable of giving it a strong magnetic action on the compass, the upper end becoming a south pole; and the lower a north pole; and that, on inverting the bar, another blow was found sufficient to change the polarity formerly given to it. But one of the most curious and important effects of percussion observed by Mr S. was found to be this, that a blow, struck upon any part of a bar of iron, while held in the plane of the magnetic equator, (which is horizontal E. and W., or with the north end elevated about 19 degrees above the horizontal in this country,) has an invariable tendency to destroy its magnetic action, which it generally does so effectually as to prevent its exerting any influence over a compass, when presented to it in the same plane of the magnetic equator.

Mr Scoresby was led to apply this property to some important purposes. Previously no other method was known of freeing iron or steel completely from magnetism, but that of heating it red-hot, and allowing it to cool in a horizontal position east and west. This process, however, besides spoiling the surface of the metal, is troublesome, and seldom completely effectual in its application. But the same object is accomplished, in a moment, and with infinitely better effect, by Mr Scoresby's process, merely by a slight blow or two with a hammer, while the iron or steel is held in the magnetic plane, and is equally applicable to very large and heavy bars, which could not, without great inconvenience, and a fire made on purpose, be heated uniformly to a state of ignition.

Another application of this discovery, is the correction of the magnetism usually found in the balances of chronometers, which produces a serious error in the rate of some instruments. Mr S. found, that any other mechanical action on iron was productive of magnetism, as well as that of percussion, though not in an equal degree. Thus, the diffe-

rent actions of grinding, filing, polishing, drilling, turning, twisting, bending, &c. were all found to elicit magnetic attraction, when performed in a vertical position, or any position out of the magnetic plane; but that the same processes were destructive of polarity, when performed on a bar or plate of untempered metal, when held in the plane of the magnetic equator. Hence, the balances of chronometers, which are usually formed principally of steel, become magnetic in turning them into form, perhaps in a vertical plane, and polishing them in a horizontal plane; but the acquisition of magnetism would no doubt be prevented, and even destroyed if they had previously obtained it, by performing these processes in the plane of the magnetic equator.

The next branch of this science to which Mr S. seems to have turned his attention, was the examination of the laws of percussion, in developing magnetism in different kinds of ferruginous substances, the investigation of the best processes for carrying the magnetism elicited by this means to its highest effect, and the application of the results obtained to useful and practical purposes.

1. Mr Scoresby found that soft steel received the greatest degree of magnetic energy by percussion. In soft iron the magnetism was strong but evanescent. In hard steel and cast-iron weak, but permanent. 2. A bar of soft steel, 6$\frac{1}{2}$ inches in length, $\frac{1}{4}$ inch in diameter, weight 392 grains, hammered in a vertical position, while held on a surface of metal not ferruginous, or even upon iron or steel, if placed horizontally, like the surface of an anvil, or upon a mass of stone, acquired, after seventeen blows, a lifting power of 6$\frac{1}{2}$ grains; but a repetition of the blows was productive of no higher energy.

"As magnetism in steel is more readily developed by the contact of magnetizable substances, and particularly if these substances, be already magnetic," it occurred to Mr S., "that the magnetizing effects of percussion might be greatly increased, by hammering the steel-bar with its lower end resting on the upper end of a large rod of iron or soft steel, both the masses being held in a vertical position; and that, if the rod were first rendered magnetic by hammering, the effect on the bar would probably be augmented*." The experiments instituted to ascer-

* *Phil. Trans.* 1822, p. 245.

tain the effect of such treatment fully proved that these opinions were correct.

The same soft steel-bar that could only be made to lift 6½ grains when hammered while resting upon a surface of stone or metal not ferruginous, when hammered vertically upon a parlour poker, also held erect, lifted a nail of 88 grains weight, after twenty-two blows. "When the poker had been previously hammered in a vertical position, an increase of magnetic effect on the bar was obtained, a single blow being now sufficient to enable the bar to lift about 20 grains;" and, in one instance, ten blows produced a lifting power of 188 grains in the bar, being nearly one-third of its own weight.

A single blow struck upon the bar when held with the other end up, almost destroyed its magnetism, and two additional blows changed its poles.

A difference of power was found to be obtained by using bars of different lengths; that is, there was an increase of attraction in bars of the same diameters, when the lengths were increased.

2. In another series of experiments, Mr S. found, that small or slender bars acquired a much greater lifting power, in proportion to their weight, than large bars. Thus, a piece of a knitting needle, 3 inches long, and weighing 28 grains, which was found to be free from magnetism before the experiment, was made to lift 54 grains, or very nearly twice its own weight, by being repeatedly hammered, while held vertically on the top of a kitchen poker.

The quantity of magnetism developed by this process, Mr S. found increased by a frequent repetition of the experiment with the same bars. Though it was necessary to use the same end downward, generally in the production of the highest effect, it did no harm to knock the magnetism occasionally out by inverting the bars. It is necessary to observe, that, in trying the lifting power of bars or needles after hammering, the nails, which are the most convenient to be used for this purpose, should have their points filed smooth round, and partly polished; otherwise the bad contact occasioned by the oxide on the point or head of the nail, may cause the experiment apparently to fail. With this precaution, there is little doubt of any one succeeding in the experiments, using only a hammer, a poker (previously struck a few blows while held vertically,) and a piece of steel wire not tempered.

3. The practical application of this discovery by Mr S., is the formation of artificial magnets, and the ready construction of a compass, without the use of a magnet, at sea.

"Such a high degree of magnetic energy, says he, being obtained by a process so simple, it suggested a ready means of making magnets, without the use of any magnetized substance whatever, and of giving polarity to needles, so as to render them capable of answering the purpose of compasses, in an instant. This application of the process induces me to be more explicit on this incidental subject, because of its importance to seafaring persons. There are instances on record, of the compasses of ships being spoiled by lightning*: The above process would enable the navigator to restore sufficient polarity for the guidance of his ship, in a few seconds. And, in cases of vessels foundering at sea, or being destroyed by fire or lightning, in which the crew are compelled to take refuge in the boats at a moment's warning, and without having time to secure a compass, (a case which has occurred hundreds of times,) the same process might enable the distressed voyagers to give polarity to the blade of a penknife, or the limb of a pair of scissors, or even to an iron nail, which would probably be sufficient, when suspended by a thread, to guide them in their course through their perilous navigation."

We have seen Mr Scoresby's experiment illustrative of the practicability of this. He used a small bar of soft steel, with a hole drilled two-thirds through it, so as to be capable

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* In the Philosophical Transactions (vol. xi. p. 647.,) is an account of a stroke of lightning received on a vessel in the parallel of Bermudas, which carried away the foremast, split some of the sails, and damaged the rigging: and, in addition to these extraordinary effects, it inverted the polarity of the compass, so that the north point became directed towards the south. This induced the navigators, who were not aware of the change, to steer back again, supposing that the wind had shifted; and it was not until they were accidentally set right by another ship, that they discovered the truth.

Another circumstance a good deal similar to this, also mentioned in the Philosophical Transactions, occurred in the year 1748—9, on the 9th of January. The ship Dover, on its way from New-York to London, was struck by lightning during a fierce storm, which was encountered in the latitude of 47° 30′ N. and longitude 22° 15′ W. On receiving the shock, the captain, and most of the crew, were for a while disabled in their limbs, or by blindness,—the main-mast was almost perforated,—the upper and lower decks and quick work were stove,—the cabins, bulk-heads, and one of the main lodging-knees of the beams were started or drove down: and, among several other singular circumstances, the magnetism of all the compasses (four in number) was destroyed, or the poles inverted.

of turning on the point of a needle. One blow with a hammer when it was held vertically on a poker, gave it such magnetic energy, that it traversed with great celerity.

"Being desirous, says he, of applying the process to the construction of powerful artificial magnets, I prepared, with the assistance of the armourer on board, six bars of soft steel, and bars properly tempered, suitable for a large compound magnet. The soft steel bars were nearly eight inches long, half an inch broad, and a sixth of an inch thick. The bars for the compound magnet, seven in number, which were of the horse-shoe form, were each two feet long before they were curved, and eleven inches from the crown to the end, when finished, one inch broad, and three-eighths thick. These bars were combined by three pins passing through the whole, and screwing into the last; and any number of them could be united into one magnet, by means of a spare set of pins screwed throughout their length, and furnished with nuts. In addition to these bars, &c. I provided separate feeders or conductors of soft iron, suitable for connecting the poles of each of the bars of the compound magnet, and also another conductor, fitted to the whole when combined. With this apparatus, I proceeded to give the magnetic virtue as follows.

"I took a rod of soft steel, which I considered better than a poker, and hammered it for a minute or two, while held vertically upon a large bar of soft iron in the same position. This gave considerable magnetism to the steel-rod. On the top of this, I then hammered each of the six bars of soft steel, until the accession of lifting power ceased. Then fixing two of them on a board, with their different poles opposite, and formed, by a feeder at each end, into a parallelogram, I rubbed these, after the manner of Canton*, by means of the other four bars, and found their magnetism greatly augmented. The other four bars were operated upon in pairs, in a similar way, those already strengthened being used for strengthening the others, and each pair being successively changed, until all the bars were found to be magnetized to saturation. A pair of them now possessed a lifting power of two pounds and a half.

"The next step was to touch the bars intended for the compound magnet, by means of these six bars now magnetized. For this purpose, the six bars were combined

* See *Phil. Trans.*, vol. xlvii. p. 31.

into two magnets, by tying three of them together, with similar poles in contact; these two were then placed, with opposite poles, in connection, and tied together at one end, but separated about the third of an inch at the other, so as to form one compound magnet, and a conductor was kept constantly applied to the open end of it, when not in use, to preserve the power from being lost. One of the bars of the horse-shoe magnet, with a conductor placed across the poles, was now placed on a board, in a groove cut out so as to hold it fast under the operation. The straight bar magnet was then placed erect on the middle of it, with the separated poles downward, and rubbed against the horse-shoe bar, from the middle to one of its poles, until the north pole of the one was in connection with the pole intended to become south of the other; from thence it was rubbed back again, with the south pole of the magnet in advance, as far as the other extremity, or that intended for the north pole of the horse-shoe bar. Two or three strokes of this kind being made from end to end of the bar, on each side of it, the north and south poles of the magnet being always directed to the south and north poles of the bar respectively, the magnet was slipped sideways off, when at the pole of the bar, and the bar was found to have acquired such a magnetic power as to enable it to sustain a weight of several ounces, hung from the conductor. Each of the bars of the horse-shoe magnet was treated this way in succession, and then the first five bars of the magnet being combined by the screws, were employed in the same way as the soft steel magnet had been used, for increasing the power of the sixth and seventh bars, by which they were rendered capable of carrying above two pounds weight each. These were then substituted, in the combined magnet, for the fourth and fifth bars, while the latter underwent the touch of the other five in combination; and, in their turn, the second and third, and then the seventh and first, were subjected to a similar treatment. After these operations, which occupied forty-three minutes, the compound magnet, with all the seven bars in connection, lifted ten pounds. After a second series of the same kind of manipulations, five of the bars in combination, carried fifteen pounds; and, after a third series, eighteen pounds; but as, on trying a fifth series, little augmentation took place, the process was discontinued.

"The whole of the operations, from beginning to end, occupied above four hours; but, as I generally rubbed each bar with twelve strokes on each side, instead of one or two,

which I afterwards found sufficient; and, in other parts of the process, spent a great deal of time and labour which turned to no account; I doubt not but the whole might have been completed, beginning without the smallest perceptible magnetism, and ending with a lifting power of twenty or thirty pounds, in the space of two hours, or less*.

"As steel does not receive, immediately on being touched, the full degree of magnetic energy of which it is susceptible, a conductor was applied to the magnet now formed; and it was laid aside, with the view of augmenting its power on a subsequent occasion†."

The errors produced in the rates of chronometers, by the magnetism of their balances, a subject of great consequence to navigators, has occupied a good deal of the attention of Captain Scoresby.

It has long been known that when chronometers are taken to sea, a change is generally found to take place in the rate determined on shore.

"This change of rate," says Mr Scoresby, "that had usually been supposed to arise from the motion of the ship, has recently been attributed, by Mr Fisher, who accompanied Captain Buchan in his Voyage towards the North Pole in the year 1818, 'to the magnetic action exerted by the iron in the ship upon the inner rim of the chronometer's balance, which is composed of steel.' I apprehend, however, that it will be very easy to show, that, although the alteration of rate may be, and most probably is, owing to magnetism, yet the magnetic action of the iron in the ship, excepting in cases where chronometers are placed in immediate contact with large masses of iron, can contribute but in a very small degree to the error in question. For, in the same proportion as the magnetism of the earth, or the directive force on the compass-needle, exceeds the magnetism of the ship, or the deviating force, the influence of terrestrial magnetism on the chronometer, must, I conceive, exceed that influence exerted by the iron in the ship on the chro-

* "Canton, it is well known, produced magnets by means of a poker and tongs, with bars of soft steel. His process being fully stated in the Philosophical Transactions, some of the above details would perhaps be anticipated by the reader; but they may not be uninteresting to those who are little acquainted with the subject, especially as the fundamental process is original, and much more ready and efficient, I apprehend, than that of Canton, one blow with a hammer being capable of developing as much magnetism as a quarter of an hour's labour with a poker and tongs."

† *Journal of a Voyage to Greenland*, p. 56.

nometer. A modified action, indeed, takes place where the direction of the magnetic force of the earth differs from the direction of the "local attraction" of the "ship;" but yet the combined influences of the two forces, however modified by direction, should, I imagine, be similar on the balance of the chronometer, which vibrates in a horizontal position, to what it is on the compass-needle, which traverses in the same position.

"Now, the medium effect of the attraction of the iron in vessels on the compass, in he parallels of Great Britain, does not appear to exceed five degrees of deviation on each side of the magnetic meridian; it is probably a little less. The force producing the deviation, therefore, is represented by the sine of the angle of deviation, or 5°; while the directive force is represented by the sine of 85°. The relation of these two, is as 1 to 11.35; that is, the directive influence of the earth's magnetism on the compass is $11\frac{1}{3}$ times greater than the deviating influence of the local attraction. Hence, the proportion of error due to the local attraction of the ship, would appear not to exceed, in these latitudes, the eleventh or twelfth part of that resulting from the earth's magnetism; while, nearer the equator, this proportion of error must be still less. So long as the action of terrestrial magnetism, therefore, remains uncorrected, it will be of little service to compensate for the error arising from the local attraction. In the Polar Seas, indeed, the force of local attraction approaches the directive force much nearer than in the British Seas; and, in some situations very near the Magnetic Poles, exceeds it; but still the local attraction operates without any increase of force, excepting what may arise from the little augmentation of the magnetic intensity of the earth in those regions; so that, in reality, the rate of a chronometer in polar regions, where the earth's magnetism acts nearly at right angles to the plane of the balance, could the effect of temperature on the instrument be perfectly compensated, ought to be more equable than in any other region, where the direction of terrestrial magnetism is more nearly in the plane in which the balance vibrates.

"In the important and truly scientific experiments of Mr Barlow, on the effects produced on the rates of chronometers by the proximity of masses of iron, we have a corroboration of the preceding opinions; for Mr Barlow, though he observed that a variation of rate was occasioned by the influence of a mass of iron equivalent to the local attraction of a ship, found by no means so great effects as those observed

by Mr Fisher. But the force of terrestrial magnetism acting upon a balance that is magnetic, is fully sufficient to account for every change of rate observed.

"Mr S. Varley, in a paper in *Tilloch's Philosophical Magazine*, published in the year 1798, was the first, I believe, who showed that an irregularity observed in the rate of some time-pieces, was owing to the magnetic state of their balances. He was directed to the inquiry by a watch of excellent workmanship that he had in his possession, which performed the most irregularly of any watch he had ever seen. It occurred to him that the cause might be magnetism; and, on examining the balance, he found it so strongly magnetic, that, when suspended horizontally without the spring, it directed itself like a compass-needle in a certain position, which it invariably returned to when it was disturbed. The pendulum spring being put on, and the balance replaced in the watch, Mr Varley laid the watch with the dial upward, and the north pole of the balance, as determined by the previous experiment, towards the north;—in this situation it *gained* 5′ 35″ in twenty-four hours. He then directed the north-pole of the balance towards the south, every thing else being as before, and it now *lost* 6′ 48″ in twenty-four hours. Mr Varley afterwards took away the steel-balance, and substituted one made of gold; then having brought the watch to time, he carefully observed its rate, and found it as uniform as any watch of like construction. He subsequently examined many dozens of balances, out of which he could not select one that had not polarity*."

The instance observed by Mr Varley was, no doubt an extreme one; but analogous effects are not uncommon. Captain Scoresby made a number of experiments on the rates of chronometers in different positions, and found, that in twelve or fourteen chronometers, a sensible alteration of rate took place in about one-half of them, without any alteration of position.

"In a pocket chronometer," says he, "by Allen and Caithness, the rate was very uniform in two positions (namely, with the 12 o'clock mark towards the NE. and SW.;) but on shifting it from NE. to SE., a change of 1″.5 took place in its rate. In another chronometer by Hatton, there appeared to be a difference of rate of about a second in two opposite positions. In a one-day chronometer by Lither-

* *Edinburgh Transactions*, vol. ix. p. 353.

land and Davies, there was scarcely any perceptible variation in three positions, namely N., S. and E.; but, on the 12 o'clock mark being directed towards the W., a change of one second per day occurred. In another instrument by the same makers, between the NW. and SE. positions, there was a difference, by the first experiment, of 2".3 per day, and by the second experiment, of 1".1. In an eight-day chronometer, by Margetts, there was also a sensible effect produced by an alteration of position. But the most extraordinary result was with an eight-day chronometer. When the position was kept uniform, the rate of this instrument was very fair: but, on shifting it from NE. to SW., it was retarded 4".4 daily. On restoring it to its first position, it was again accelerated even beyond its former rate. The same change was repeatedly made; and in all cases, an alteration of from 4".4 to 9".5 per day occurred; and, in every instance when the change was made from NE. to SW., the rate was retarded; when the contrary way, accelerated! Between the positions of SE. and NW., there was also a difference of rate, but it was not very considerable.

"As the experiments with the last instrument were by far the most decisive, I was desirous of examining the balance,—a wish that Mr Davies very readily gratified. It was found to be strongly magnetic, acting with great energy on a small needle, at the distance of more than an inch. Mr Davies having got rid of the greater part of the magnetism of this balance, restored it to its place, when the change of rate, by changing its position, though it did not entirely disappear, was got reduced to about one-fourth. The balance of another chronometer by the same makers, whose rate in all positions was remarkably uniform, was also examined, and it was satisfactory to find that it was entirely free from magnetism*."

Captain S. we have observed, proposes to get rid of the magnetism in the balances of chronometers, by turning and grinding them in the plane of the magnetic equator. But he suggests another means of rectifying the errors of chronometers, where balances are magnetic, by suspending them on an instrument, called a *Chronometrical Compass*, which he has contrived for the purpose, and which always keeps them in the same position at sea, with respect to the magnetic meridian. This instrument consists of a slender cross of brass,

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* *Journal of a Voyage to Greenland*, p. 9.

supported on a long point of brass or steel in a compass bowl, from which is suspended a rhomboidal compass-needle. On the centre of the brass cross there is a light case of card paper fitted to the pocket-chronometer to be carried by it. The case for the chronometer slips upon two pins rivetted to a moveable plate upon the cross, which being made to slide in different directions, may be so placed as to adjust the chronometer fairly over the centre of the needle, and is then fastened by screws. In this state, the magnetic needle below it causes the cross and chronometer to traverse with great celerity. It therefore has the property of keeping the chronometer invariably in the same position, and, being suspended on gimbals, of preserving it from the bad effects of the motion of the ship at sea. The magnetic needle was hung five or six inches below the chronometer, so that its influence on the instrument was not greater than that of the earth; and, being in an opposite direction, has a tendency to neutralize, rather than add to, this disturbing cause*.

This apparatus was tried at sea, and proved to answer the desired purpose in a most admirable manner. In one of the heaviest gales experienced on Captain Scoresby's last voyage, the chronometer on the apparatus traversed perfectly, and was steadier than any of the compasses.

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## Art. LIII.—*On Chloride of Lime or Bleaching Powder.* By Andrew Ure, M. D. F. R. S., &c.†

Chloride of Lime, the bleaching salt or bleaching powder of Mr Tennant is called in commerce Oxymuriate of Lime.

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* This instrument is described in the *Edin. Trans.* vol. ix. p. 364.

† This article is taken from Dr Ure's Dictionary of Chemistry, Edition 1823, and was first published in the Journal of Science and the Arts. We should not have devoted the pages of our Journal to matter taken from a systematic work; but in the present case we have thought the importance of the subject, together with the scientific manner in which it is treated, would form a sufficient apology.—*Ed. Bos. Journal.*

In the researches which I have made, at many different times, on the nature of the chloride of lime, I have generally sought to combine the information flowing from both synthesis and analysis; that is, I first converted a known portion of hydrate of lime into bleaching powder, and then subjected this to analysis. Among the results of experiments in my note-book of 1815, I find the following: 500 grains of unslacked quick lime, in fine powder, from Carrara marble, were exposed in a glass globe to a copious stream of chlorine, previously passed through a little cold water, for four days. The increase of weight was noted from time to time, and was found, at the end of that period, to be only 30 grains, which subsequent examination shewed to be due to a little hydrated chloride; the few grains of water requisite having been derived from the great body of undried gas which had been transmitted. In May 1817, an experiment is recorded, in which 400 grains of a hydrate of Carrara lime, equivalent to 291.28 grains of dry lime, were exposed for two days to a stream of chlorine, washed in water of 50°, and refusing to absorb more gas, were found heavier by 270.5 grains. Supposing this augmentation to be chlorine, we shall have the composition of the powder, by the synthetic mode, as follows:

| | | | |
|---|---|---|---|
| Chlorine, | | | 40.34 |
| Dry lime, | 43.46 | Hydrate, | 59.66 |
| Water, | 16.20 | | |
| | | | 100.00 |

This powder was analyzed, by acting on a given weight of it with dilute muriatic acid, in a pear-shaped glass vessel. Care was taken to remove the whole disengaged chlorine, without letting any liquid escape. The lime was converted into carbonate, by a solution of carbonate of ammonia. The following are the results of two independent analytical experiments:

| | 1st Experiment. | 2d Experiment. |
|---|---|---|
| Chlorine evolved, | 40.60 | 39.40 |
| Lime, | 42.27 | 42.22 |
| Water, | 17.13 | 18.38 |
| | 100.00 | 100.00 |

I have reason to believe the second experiment the more correct of the two, and if the synthetic result be compared

with it, we are led to infer that the very great body of undried chlorine passed over the lime had deposited two per cent of water. By other experiments I satisfied myself, that dilute muriatic acid expelled nothing but pure chlorine, for the whole gas disengaged is absorbed on agitation with mercury. It does not appear possible to reconcile the above chlorides to a definite atomic constitution. The following experiments were made with much care last spring:

200 grains of the atomic protohydrate of pure lime were put into a glass globe, which was kept cool by immersion in a body of water at 50°. A stream of chlorine, after being washed in water of the same temperature in another glass globe, connected to the former by a long narrow glass tube, was passed over the calcareous hydrate. The globe with the lime was detached from the rest of the apparatus from time to time, that the process might be suspended as soon as the augmentation of weight ceased. This happened when the 200 grains of hydrate, containing 151.9 of lime, had absorbed 130 grains of chlorine. By one analytical experiment it was found, that dilute muriatic acid expelled from 50 grains of the chloride 20 grains of chlorine, or 40 per cent; and by another, from 40 grains 16.25 of gas, which is 40.6 per cent. From the residuum of the first, 39.7 grains of carbonate of lime were obtained by carbonate of ammonia; from that of the second, 36.6 of ignited muriate of lime. The whole results are therefore as follows:

| | Synthesis. | 1st Analys. | 2d Analys. | Mean. |
|---|---|---|---|---|
| Chlorine, | 39.39 | 40.00 | 40.62 | 40.31 |
| Lime, | 46.00 | 44.74 | 46.07 | 45.40 |
| Water, | 14.60 | 15.26 | 13.31 | 14.28 |
| | 100.00 | 100.00 | 100.00 | 100.00 |

Though the heat generated by the action of the dilute acid has carried off in the analytical experiments a small portion of moisture with the chlorine, yet their accordance with the synthetic experiment is sufficiently good to confirm the general results. The above powder appears to have been a pure chloride, without any mixture of muriate. But it exhibits no atomic constitution in its proportions.

To 200 grains of that hydrate of lime, 30 grains of water being added, the powder was subjected to a stream of chlorine in the above way, till saturation took place. Its increase of weight was 150 grains. It ought to be remarked, that in this and the preceding experiment there was no ap-

preciable pneumatic pressure employed, to aid the condensation of the chlorine. In the last case, we see that the addition of 30 grains of water has enabled the lime to absorb 20 grains more of chlorine, being altogether a quantity of gas nearly equal to that of the dry lime. Thus an atom of lime seems associated with 7-9ths of an atom of chlorine. Analysis by muriatic acid confirmed this composition. It gave,

| | | |
|---|---|---|
| Chlorine, | 39.5 | = 51.8 cubic inches. |
| Lime, | 39.9 | |
| Water, | 20.6 | |
| | 100.0 | |

I next exposed some of this powder to heat in a small glass retort, connected with the hydro-pneumatic trough. Gas was very copiously disengaged, at a temperature far below ignition, the first portions coming off at the heat of boiling water; 100 measures of the collected gas being agitated with water at 50° F., 63 measures were absorbed, and the remaining 37 measures were oxygen, nearly pure. The smell of the first evolved gas was that of chlorine, after which the odour of euchlorine was perceived, and latterly the smell nearly ceased, as the product became oxygen. Having thus ascertained the general products, I now subjected to the same treatment 100 grains of the same powder (that last described,) in a suitable apparatus; 30 cubic inches of gas were obtained from it, in a series of glass cylinders, standing over water at 50°. The first received portion was chlorine, nearly pure, but towards the end, when the heat approached, or was at ignition, oxygen became the chief product. The residuary solid matter yielded to water a solution of muriate of lime, containing 30 grains of the dry salt, equivalent to about 15 of lime. But the chloride, both by synthesis and analysis, seemed to contain in 100 grains 51.8 cubic inches of chlorine, (corresponding to 25.9 of oxygen,) with 39.9 of lime. Thus the volume of the evolved gas proves, independent of other considerations, that a considerable portion of chlorine came off, without dislodging the oxygen from the calcium; and as in subsequent experiments this volume was found to vary with the strength of the powder, and the mode of heating it, this method of analysis becomes altogether nugatory and delusive. The truth of this conclusion will still further appear on reflecting, that an uncertain portion of chlorine is con-

densed in the water of the trough, and that most probably a little euchlorine is formed at the period when the gaseous product passes from chlorine to oxygen. Thus, of the 39.9 grains of lime present in the chloride, 24.9 seem to have merely parted with their chlorine, while the other 15 lost their oxygen, equivalent to 12¾ cubic inches, or 4.3 grains, and the remaining 10.7 of calcium combined with 19.3 of chlorine, to constitute the 30 grains of ignited muriate of lime. But 19.3 grains of chlorine form 25.3 cubic inches; hence 51.8 — 25.3 = 26.5 is the volume of chlorine disengaged by the heat, to which, if we add 12¾ cubic inches of oxygen, the sum 39.16 is the bulk of gas that should have been received. The deficiency of 9.16 cubic inches is to be ascribed to absorption of chlorine (and perhaps of euchlorine,) by the water of the pneumatic trough. In the above case, about one-half of the total chlorine came off in gas, and the other half combined with the basis of the lime, to the exclusion of its oxygen. I have observed, that the proportion of chlorine to that of oxygen given off by heat, increases, as one may naturally imagine, with the strength of the bleaching powder. When it is very weakly impregnated with chlorine, as is the case with some commercial samples, then the evolved gas consists in a great measure of oxygen.

### *Of the Manufacture of Bleaching Powder.*

A great variety of apparatus has been at different times contrived for favouring the combination of chlorine with slacked lime, for the purposes of commerce. One of the most ingenious forms was that of a cylinder, or barrel, furnished with narrow wooden shelves within, and suspended on a hollow axis, by which the chlorine was admitted, and round which the barrel was made to revolve. By this mode of agitation, the lime-dust being exposed on the most extensive surface, was speedily impregnated with the gas to the requisite degree. Such a mechanism I saw at MM. Oberkampf and Widmer's celebrated *fabrique de toiles peintes*, at Joüy, in 1816. But this is a costly refinement, inadmissible on the largest scale of British manufacture. The simplest, and in my opinion the best, construction for subjecting lime-powder to chlorine, is a large chamber eight or nine feet high, built of siliceous sandstone, having the joints of

the masonry secured with a cement composed of pitch, rosin, and dry gypsum in equal parts. A door is fitted into it at one end, which can be made air-tight by stripes of cloth and clay lute. A window in each side enables the operator to judge how the impregnation goes on by the colour of the air, and also gives light for making the arrangements within at the commencement of the process. As water-lutes are incomparably superior to all others, where the pneumatic pressure is small, I would recommend a large valve, or door, on this principle, to be made in the roof, and two tunnels of considerable width at the bottom of each side wall. The three covers could be simultaneously lifted off by cords passing over a pulley, without the necessity of the workman approaching the deleterious gas, when the apartment is to be opened. A great number of wooden shelves, or rather trays, eight or ten feet long, two feet broad, and one inch deep, are provided to receive the riddled slacked lime, containing generally about 2 atoms of lime to 3 of water. These shelves are piled one over another in the chamber, to the height of five or six feet, cross-bars below each keeping them about an inch asunder, that the gas may have free room to circulate over the surface of the calcareous hydrate.

The alembics for generating the chlorine, which are usually nearly spherical, are in some cases made entirely of lead, in others, of two hemispheres joined together in the middle, the upper hemisphere being lead, the under one cast-iron. The first kind of alembic is enclosed for two-thirds from its bottom in a leaden or iron case, the interval of two inches between the two being destined to receive steam from an adjoining boiler. Those which consist below of cast-iron, have their bottom directly exposed to a very gentle fire; round the outer edge of the iron hemisphere a groove is cast, into which the under edge of the leaden hemisphere sits, the joint being rendered air-tight by Roman or patent cement*. In this leaden dome there are four apertures, each secured by a water-lute. The first opening is about ten or twelve inches square, and is shut with a leaden valve, with incurvated edges, that sit in the water-channel at the margin of the hole. It is destined for the

* A mixture of lime, clay, and oxide of iron, separately calcined, and reduced to a fine powder. It must be kept in close vessels, and mixed with the requisite water when used.

admission of a workman to rectify any derangement in the apparatus of rotation, or to detach hard concretions of salt from the bottom. The second aperture is in the centre of the top. Here a tube of lead is fixed, which descends nearly to the bottom, and down through which the vertical axis passes, to whose lower end the cross bars of iron, or of wood, sheathed with lead, are attached, by whose revolution the materials receive the proper agitation for mixing the dense manganese with the sulphuric acid and salt. The motion is communicated either by the hand of a workman applied from time to time to a winch at top, or it is given by connecting the axis with wheel work, impelled by a stream of water, or a steam engine. The third opening admits the syphon-formed funnel, through which the sulphuric acid is introduced; and the fourth is the orifice of the eduction pipe.

Manufacturers differ much from each other in the proportion of their materials for generating chlorine. In general, 10 cwt. of salt are mixed with from 10 to 14 cwt. of manganese, to which mixture, after its introduction into the alembic, from 12 to 14 of sulphuric acid are added in successive portions. That quantity of oil of vitriol must, however, be previously diluted with water, till its specific gravity becomes about 1.65. But, indeed, this dilution is seldom actually made, for the manufacturer of bleaching powder almost always prepares his own sulphuric acid for the purpose, and therefore carries its concentration no higher in the leaden boilers than the density of 1.65, which, from my table of sulphuric acid, indicates 1-4th of its weight of water, and therefore 1-3d more of such acid must be used.

The fourth aperture, I have said, admits the eduction pipe. This pipe is afterwards conveyed into a leaden chest, or cylinder, into which all the other eduction pipes also terminate. They are connected with it simply by water-lutes, having a hydrostatic pressure of 2 or 3 inches. In this general *diversorium* the chlorine is washed from adhering muriatic acid, by passing through a little water, in which each tube is immersed, and from this the gas is led off by a pretty large leaden tube, into the *combination room*. It usually enters in the top of the ceiling, whence it diffuses its heavy gas equally around.

Four days are required, at the ordinary rate of working, for making good marketable bleaching powder. A more rapid formation would merely endanger an elevation of tem-

perature, productive of muriate of lime, at the expense of the bleaching quality. But skilful manufacturers use here an alternating process. They pile up, first of all, the wooden trays only in alternate shelves in each column. At the end of two days the distillation is intermitted, and the chamber is laid open. After two hours the workman enters, to introduce the alternate trays, covered with fresh hydrate of lime, and at the same time rakes up thoroughly the half-formed chloride in the others. The door is then secured, and the chamber, after being filled for two days more with chlorine, is again opened, to allow the first set of trays to be removed, and to be replaced by others containing fresh hydrate, as before. Thus the process is conducted in regular alternation; thus, to my knowledge, very superior bleaching powder is manufactured, and thus the chlorine may be suffered to enter in a pretty uniform stream. But for this judicious plan, as the hydrate advances in impregnation, its faculty of absorption becoming diminished, it would be requisite to diminish proportionately the evolution of chlorine, or to allow the excess to escape, to the great loss of the proprietor, and, what is of more consequence, to the great detriment of the health of the workmen.

The manufacturer generally reckons on obtaining from one ton of rock-salt, employed as above, a ton and a half of good bleaching powder. But the following analysis of the operation will show, that he ought to obtain two tons.

Science has done only half her duty, when she describes the best apparatus and manipulations of a process. The *maximum* product should be also demonstrated, in order to show the manufacturer the perfection which he should strive to reach, with the *minimum* expense of time, labour, and materials. For this end I instituted the following researches:— I first examined fresh commercial specimens of bleaching powder; 100 grains of these afforded from 20 to 28 grains of chlorine. This is the widest range of result, and it is undoubtedly considerable; the first being to the second, as 100 to 71. The first yielded, by saturation with muriatic acid, 82 grains of chloride of calcium, equivalent to about 41 of lime; it contained besides 26 per cent of water, and a very little common muriate ready formed. On heating such powder in a glass apparatus, it yielded at first a little chlorine, and then oxygen tolerably pure. The bulk of chlorine did not exceed one-tenth of the whole gaseous product. Of the recently prepared powder of another manufacturer, 100 grains were found to give, by solution in acid, 23 grains

of chlorine, and there remained, after evaporation and gentle ignition, 92 grains of muriate of lime, equivalent to about 46 of lime. Supposing this powder to have been nearly free from muriate, (and the manufacturers are anxious to prevent the deliquescent tendency which this introduces,) we should have its composition as follows:—

| | | | |
|---|---|---|---|
| Chlorine, | 23 | | 3.5 |
| Lime, | 46 | one atom | $3.5 \times 2 = 7.0$ |
| Water, | 31 | | |
| | 100 | | |

This powder being well triturated with different quantities of water at 60°, yielded filtered solutions of the following densities at the same temperature:

| | | Sp. gr. |
|---|---|---|
| 95 water | + 5 bleaching powder, | 1.0245 |
| 90 | + 10 | 1.0470 |
| 80 | + 20 | 1.0840 |

The powder left on the filter, even of the second experiment, contained a notable quantity of chlorine, so that the chloride is but sparingly soluble in water; nor could I ever observe that partition occasioned by water in the elements of the powder, of which Mr Dalton and M. Welter speak. Of the solution 80 + 20, 500 grains, apparently corresponding to 100 grains of powder, gave off, by saturation with muriatic acid, 19 grains of chlorine, and the liquid, after evaporation and ignition, afforded 41.8 grains of chloride of calcium, equivalent to 21 of lime. Here 4 per cent of chlorine seem to have remained in the undissolved calcareous powder, which indeed, on examination, yielded about that quantity. But the dissolved chloride of lime consisted of 19 chlorine to 21 lime; or of 4.5 atoms of the former, to almost exactly 5 (which is no atomic proportion) of the latter. The two-thirds of a grain of lime existing in lime water, in the 500 grains of solution, will make no essential alteration on the statement. Now the above bleaching powder must have contained very little muriate of lime, for it was not deliquescent. Being thus convinced, both by examining the pure chloride of my own preparation, as well as that of commerce, that no atomic relations are to be observed in its constitution, for reasons already assigned, I ceased to prosecute any more researches in that direction.

When we are desirous of learning minutely the proportion between the chloride and muriate of lime in bleaching powder, pure vinegar may be used as the saturating acid. Hav-

ing thus expelled the chlorine, we evaporate to dryness, and ignite, when the acétate of lime will become carbonate, which will be separated from the original muriate by solution and filtration.

I have found, on trial, the method by carbonic acid to be exceedingly slow and unsatisfactory. After passing a current of this gas for a whole day through the chloride diffused in tepid water, I found the liquid still to possess the power of discharging the colour very readily from litmus paper. But the doctrine of equivalents furnishes a very elegant theorem with acetic acid, whose conveniency and accuracy in application I have verified by experiment. An apparently complex, and very important problem of practical chemistry, is thus brought within the reach of the ordinary manufacturer. Since common fermented vinegar is permitted by law to contain a portion of sulphuric acid, which avarice often leads the retailer to increase, we cannot employ it in the present research. But strong vinegar prepared from pyrolignous acid, such as that with which Messrs Turnbull and Ramsay have long supplied the London market, being entirely free from sulphuric acid, is well adapted to our purpose. With such acid, contained in a poised phial, fully saturate a given weight (say 100 grains) of the bleaching powder, contained in a small glass matrass, applying a gentle heat at last, with inclination of the mouth of the vessel, to expel the adhering chlorine. Note the loss of weight due to the disengagement of the gas. (If carbonic acid be suspected to be present, the gas may be received over mercury.) Evaporate the solution, consisting of acetate and muriate of lime, to dryness, by a regulated heat, and note the weight of the mixed saline mass. Then calcine this, at a very gentle red heat, till the acetic acid be all decomposed. Note the loss of weight. We have now all the *data* requisite for determining the proportion of the constituents without solution, filtration, or precipitation by reagents.

Problem I.—To find the lime originally associated with the chlorine, or at least *not* combined with muriatic acid, and therefore converted into an acetate. *Rule.*—Subtract from the above loss of weight its twenty-fifth part, the remainder is the quantity of lime taken up by the vinegar.

Problem II.—To find the quantity of muriate of lime in the bleaching powder. *Rule.*—Multiply the above loss of weight by 1.7, the product is the quantity of carbonate of lime in the calcined powder, which being subtracted from the total weight of the residuum, the remainder is of course

the muriate of lime. We know now the proportion of chlorine, lime, and muriate of lime, in 100 parts; the deficiency is the water existing in the bleaching powder. Thus, for example, I found 100 grains of a commercial chloride some time kept, to give off 21 grains of chlorine, by solution in dilute acetic acid. The solution was evaporated to dryness: of saline matter 125.6 grains were obtained, which, by calcination, became 84.3, having thus lost 41.3 grains. But $41.3 - \frac{41.3}{25} = 39.65 =$ lime present, uncombined with muriatic acid. And $41.3 \times 1.7 = 70.2 =$ the carbonate of lime in the residuary 84.3 grains of calcined salts. Therefore, $84.3 - 70.2 = 14.1 =$ muriate of lime. Now, by dissolving out the muriate of lime, and evaporating, I got 14 grains of it, and the remaining carbonate was 70.3 grains. Hence this powder consisted of chlorine 21, lime 39.65, muriate of lime 14, and water $25.35 = 100$.

Sulphate of indigo, largely diluted with water, has been long used for valuing the blanching power of chloride of lime; and it affords, no doubt, a good comparative test, though from the variableness of indigo it can form no absolute standard. Thus I have found 3 parts of indigo, from the East Indies, to saturate as much bleaching powder as 4 parts of good Spanish indigo.

M. Welter's method is the following:—He prepared a solution of indigo in sulphuric acid, which he diluted, so that the indigo formed $\frac{1}{1000}$ of the whole. He satisfied himself by experiments, that 14 litres (854.4 cubic inches, or 3.7 wine gallons English) of chlorine, which weigh 651½ English grains, destroyed the colour of 164 litres of the above blue solution. He properly observes, that chlorine discolours more or less of the tincture, according to the manner of proceeding, that is, according, as we pour the tincture on the aqueous chlorine, and as we operate at different times, with considerable intervals; if the aqueous chlorine or chloride solution be concentrated, we have the *minimum* of discoloration; if it be very weak, the *maximum*. He says, that solution of indigo, containing about $\frac{1}{1000}$ part, will give constant results to nearly $\frac{1}{40}$; and to greater nicety still, if we dilute the chlorine solution, so that it shall amount to nearly one-half the volume of the tincture which it can discolour; if we use the precaution to keep the solution of chlorine and the tincture in two separate vessels; and, finally, to pour both together into a third vessel. We should, at the same time, make a trial on another sample of chlorine

whose strength is known, in order to judge accurately of the hue. On the whole, he considers that fourteen measures of gaseous chlorine can discolour 164 measures of the above indigo solution, being a ratio of nearly one to twelve. The advantage of the very dilute tincture obviously consists in this, that the excess of water condenses the chlorine separated from combination by the sulphuric acid, and confines its whole efficacy to the liquor; whereas, from concentrated solutions, much of it escapes into the atmosphere. Though I have made very numerous experiments with the indigo test, yet I never could obtain such consistency of result as M. Welter describes: when the blue colour begins to fade, a greenish hue appears, which graduates into brownish-yellow by imperceptible shades. Hence an error of $\frac{1}{16}$ may readily be allowed, and even more, with ordinary observers.

When a mixture of sulphuric acid, common salt, and black oxide of manganese, are the ingredients used, as by the manufacturer of bleaching powder, the absolute proportions are—

| | | | |
|---|---|---|---|
| 1 atom mur. of soda, | 7.5 | 29.70 | 100.0 |
| 1 atom perox. of mang. | 5.5 | 21.78 | 73.3 |
| 2 at. oil of vit. 1.846 | 12.25 | 48.52 | 163.3 |
| | 25.25 | 100.00 | |

And the products ought to be—

| | | | |
|---|---|---|---|
| Chlorine disengaged, | 1 atom | 4.5 | 17.82 |
| Sulphate of soda, | 1 | 9.0 | 35.64 |
| Protosulphate of mang. | 1 | 9.5 | 37.62 |
| Water, - - - - - - | 2 | 2.25 | 8.92 |
| | | 25.25 | 100.00 |

These proportions are, however, very different from those employed by many, nay, I believe, by all manufacturers; and they ought to be so, on account of the impurity of their oxide of manganese. Yet making allowance for this, I am afraid that many of them commit great errors in the relative quantities of their materials.

From the preceding computation, it is evident that 1 ton of salt with 1 ton of the above native oxide of manganese properly treated, would yield 0.59 of a ton of chlorine, which would impregnate 1.41 tons of slacked lime, producing 2 tons of bleaching powder, stronger than the average of the

commercial specimens; or allowing for a little loss, which is unavoidable, would afford 2 tons of ordinary powder, with a little more slacked lime.

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ART. LIV. *On the Changes which have taken place in the Declination of some of the principal Fixed Stars. By* JOHN POND, *Esq. Astronomer Royal, F. R. S.* [*Phil. Trans.*]

THE mural circle having in September last been put into complete repair, and declared by Mr Troughton to be in as perfect a state as when first erected, I resumed my examination of the principal fixed stars which form the Greenwich catalogue. In the course of a very short time, I found that several anomalies, which had previously given me much perplexity, still subsisted: some of these were of such a nature as to lead to a suspicion that a change might possibly have taken place in the figure of the instrument; on the other hand, there were circumstances that strongly militated against such a supposition.

Several of the stars in which the supposed discordance appeared the greatest, passed over almost the same divisions with others, in which no such discordance could be perceived. Moreover, in examining these discordances in different points of view (that is, both with respect to their right ascensions and polar distances,) I fancied I perceived something like a general law, that was quite incompatible with any possible hypothesis of error in the instrument.

On a point of this importance, I clearly saw the necessity of devising some new method of observation which might decide with certainty that which otherwise would become an endless subject of doubt and conjecture.

I had often attempted to observe the altitudes of stars by means of an artificial horizon of quicksilver, or other fluid, but had abandoned the attempt from the difficulty of protecting it from the wind, and from the number of observations I lost in fruitless experiments. To this method I had again recourse; and by means of wooden boxes of different sizes and figures, according to the different altitudes of the stars, I have sufficiently accomplished my purpose. A very few observa-

tions were sufficient to convince me that the instrument was in every respect perfect, and that I might repose the greatest confidence in every result it gave.

Several stars, and particularly those most discordant, I have observed by this new method, and find their places, without any exception, to agree within a fraction of a second with those determined by direct measurement from the pole.

Presuming that the observations* which accompany this paper will remove every shadow of a doubt as to the accuracy of the instrument, I shall now proceed to state, in as few words as possible, the nature of the changes which appear to me to have taken place since the year 1812.

If Bradley's catalogue of stars for the year 1756 be compared with the Greenwich catalogue for 1813, it will be possible to deduce the annual variation for each star for the mean period, or for the year 1784, on the supposition of uniformity in the proper motion of each star; then allowing for the change of precession for each star, a catalogue may be computed for any distant period; as for example, the present year 1822. Suppose such a catalogue computed, which I have named a predicted catalogue; then, if this be compared with the observed catalogue for the same year, the following differences will be found to subsist between them.

The general tendency of all the stars will be to appear to the south of their predicted places, and this tendency seems to be greater in southern than in northern stars: if any star be found north of its predicted place, it will always be a star north of the zenith, and the quantity of its motion extremely small. There may be observed a much greater tendency to southern motion in some parts of the heavens than in opposite or distant parts as to right ascension, and in much the greater portion of the heavens the southern motion seems to prevail. A southern star, as *Sirius*, situated in that part of the heavens most favourable for southern motion, will be found more to the south of its predicted place than *Antares*, situated in the part least favourable for southern motion, though it is itself more southward.

Several stars have moved more from their predicted places than other neighbouring stars: when this happens, the motion is always southward; I have yet met with no exception to this rule; not a single star can be found having an *extra* tendency to northern motion; and indeed the northern motion

* Vide Philos. Trans.

in any star is so very small, that it would never have excited attention.

A very great deviation will be found in three very bright stars, *Capella*, *Procyon*, and *Sirius*: the proper motion of each of these is southward; it therefore follows that these proper motions are accelerated. The proper motion of *Arcturus* is very great, and likewise southward. It is situated in that part of the heavens where the southern tendency is least discernible, and is nearly quiescent; its proper motion in polar distance may therefore be considered as uniform. There is a circumstance that deserves notice, though it may be merely accidental: the stars in the Greenwich catalogue, whose proper motions are south, nearly equal in number those that are north, yet the *quantity* of southern proper motion exceeds the northern in the proportion of four to one.

I shall at present offer no conjecture on the cause of these deviations, but endeavour, by continued observations, more accurately to ascertain the law which they follow.

Mr Pond then gives the result of several observations from which he concludes that the instrument has no deviation either from flexion of the telescope, or change of figure; and in another paper, which may be considered as an appendix to the above, he treats on the probability of errors, connected with the observations at more length. Our limits prevent us from copying this part of his paper. He then proceeds:

In illustration of the whole of the preceding observations, et us examine two catalogues, those of Dr Brinkley and Mr Bessel, which have lately much excited the attention of astromomers. It is obvious, by merely inspecting these catalogues, a comparison of which with the Greenwich catalogue I here subjoin, that one or both of the instruments used by these astronomers must be erroneous; and it seems to me, that the source of error is the very flexure, the nature and effects of which we have been considering. For, if we attend to the differences between these two catalogues, we shall find that the six stars near the equator differ 5″ from one another, whereas the stars near the zenith do not differ above 2″.5. In which direction flexure will effect the zenith distances, is a matter quite accidental, depending on the unequal elevation or depression of the object-end or eye-end of the telescope, in consequence of the unequal strength of the materials. If we suppose error to exist in each of the catalogues, this cause must have had an opposite influence in the two cases: if we

compare the Greenwich observations with those of Dr Brinkley, we shall arrive at the same conclusion; namely, that the differences must be caused by flexure in one or both of the instruments; since here also we find that the stars in the neighbourhood of the zenith are affected only by half the difference in polar distance, that is observed in the stars near the equator; and the same conclusions may be drawn from comparing the Greenwich observations with those of Mr Bessel. The polar distances of all the stars in Mr Bessel's catalogue exceed the polar distances given in the Greenwich catalogue; while those of all the stars in Dr Brinkley's catalogue as regularly fall short of my determinations. It is not from the casual circumstance of my results being nearly a mean between the results of those two astronomers, that I intend to claim a superior weight of authority for my own; for, were this the only ground for preference, I should regard the question as yet undetermined, and should think it my duty to recommend the providing of new and more powerful instruments for ascertaining the truth. But it appears to me that from the observations by reflection, which I have lately made, and from their agreement with my observations by direct vision, that I am entitled to determine the share of error to which each of these two catalogues is liable; not only from the general superiority of the Greenwich circle, which I consider to have been thus proved, but from this peculiar circumstance, that whereas in the two catalogues of Mr Bessel and Dr Brinkley, the errors cannot fail to be the greatest in stars near the horizon; by my method of reflection, those stars which are nearest the horizon must be determined the most correctly, from their double altitudes being measured on the smallest arc.

In stars near the equator the catalogue of Mr Bessel differs from that of Dr Brinkley five seconds; and from the preceding consideration, I think we may venture to conclude that Mr Bessel's polar distances are too great by about three seconds, and Dr Brinkley's too small by about two: and since my catalogue differs from the two former from the zenith to equator in very nearly the same proportion, there can be no reason to doubt that their errors throughout are divided in nearly the same ratio.

ART. LV.—*Remarks upon the Observatories of Europe, extracted from a memoir of Baron de Zach, written upon the occasion of a new Observatory at Marlia in the Dutchy of Lucca, founded by her Majesty Marie Louise de Bourbon,* 1819. *Correspondance Astronomique,* &c. *for* 1822.

[Communicated for this Jour. by Prof. Farrar.]

There are about *one hundred and thirty* observatories in Europe, and we are certain that we have not counted all. If they were all in active operation, provided with good instruments, conducted by astronomers of intelligence, skill, industry, and devoted attachment to the science, undoubtedly the number would be greater than is necessary. * * * * * *

But to be just, it is not always the fault of astronomers. Here there is an observatory, but no instruments; there, instruments, but no observatory; in another place, neither the one nor the other, but skilful astronomers. Moreover there are places where there is every thing that is wanted, but no astronomer, or at least none who is willing, at leisure, and at the same time competent to do what is necessary. Ten, fifteen or twenty years are employed in building and furnishing an observatory, and before it has given a single good observation, it falls to decay, and the instruments are destroyed. We do not specify instances, although it would be easy to do so. We could name an observatory, lately built, the expense of which was about a million of francs, [180,000 dollars,] which has completely failed, and the instruments belonging to which, though very valuable, are entirely ruined. We could mention another observatory, which had been in operation for forty years, but which has now done nothing for twenty-five years, and which had not succeeded in establishing its true longitude, although it was enriched with the finest instruments. Here is certainly just occasion for disgust to governments the most liberal, and the most ready to protect and encourage the sciences; and if complaints are sometimes made that in this or that particular, they have not been sufficiently patronized, by attending to the subject more closely, it will often be found, that the fault is in those who complain, rather than in those who are accused. Sometimes the failure arises from circumstances the most unlooked for. A particular government, for example, which may have a collection of good instruments, is not inclined to erect an observatory, because it would not put these instruments into the hands of an unfit person already in place. In some cases, it is known very well

how to get rid of such incumbents, in others they are suffered to remain. * * * * * * *

With respect to most observatories, there are two radical defects, which have prevented our deriving from them that general, and I may say, almost universal benefit, which they are calculated to afford. To what purpose is it to erect splendid observatories, and to adorn them with precious instruments, and to make the best possible observations, if these observations are condemned to moulder upon the shelves, to be destroyed by worms and mice, or to perish in the flames, as has often happened. * * * * * *

In all Europe, there is only the single observatory at Greenwich, in which the observations are required to be published annually. Here it is prescribed to the Astronomer Royal, as a duty, and the President and Council of the Royal Society, are obliged to see that this duty is performed.

In the other observatories of Europe, there are neither funds, nor regulations for this purpose. If some diligent and faithful astronomer wishes to publish his observations, he is obliged to apply to the government, or some branch of the civil authority, for the requisite means, for the booksellers are not charged, and ought not to be, with works of this nature. After employing much time and pains, by dint of repeated solicitations, if his patience and courage do not fail, permission is at length obtained, to print *some small matter;* but, weary with repeated unavailing efforts, he is loth to return to the charge. Exertions have long been made for the publication of the posthumous works of Tobias Mayer, who died 1762; at length, the first volume came out in 1775; the others were promised, and are still to appear [1819.] * * * * *

Thus so long as we do not provide permanent funds, destined to defray the expense of printing those observations which are worth printing, so long as we do not make it the duty of the astronomer, at the head of the observatory, to publish at stated times, all his observations, I readily grant that it is not worth while to build new observatories. * * * * * *

Another defect, with respect to many observatories, arises from the belief that it is sufficient to place over an establishment of this kind, a good mathematician, with the expectation, that he will from this time, become a good astronomer. A great mathematician is seldom fond of long continued observations; he accustoms himself with difficulty to the evening air and nocturnal fatigue; he has not always that ardour and patience, so necessary to extreme precision, and minute exactness in observations; and these are notwithstanding, the

qualities which constitute the good observer. *Newton*, *Euler*, *Lagrange*, would probably have made poor observers. Study and application may form a good mathematician, but a good observer must have received from the hands of nature, exquisite organs, a robust constitution, an unfailing stock of health, together with a good degree of address and dexterity. No study, no application, will supply the want of these. We have never known observers of a feeble and sickly constitution, who accomplished any thing of consequence; but we have had distinguished mathematicians, whose health was very delicate.

When we have placed an astronomer in an observatory, well mounted, and furnished with good instruments, it is not to resolve problems in geometry,* to give the last finish to algebraical formulas, to purify hydrogen gas, or to light halls and theatres; we require one who *loves*, and who *knows how to use his eyes*, who is well acquainted with the heavens, who can make discoveries there, and follow with a lively interest, and exquisite tact, those that he or others have made; and he should above all things, be careful to follow the courses of the heavenly bodies, with perseverance and with intelligence.† * * * * * *

I do not say that the qualities of a good mathematician and a good observer are incompatible; it is necessary that the latter should be to a certain degree a mathematician, but I speak of those who have been, or are eminent; and I will always maintain, that such men as Halley, Gaüs, Olbers, Bessel, Littrow and Plana, are men altogether out of the common course, and will always be so. Observers like Herschel, Schroëter, Harding, Messier, Pons, &c. are of another class; but, as it is so seldom, that the two classes are found united in the same person, in order to have an observatory under good regulations, I should propose to place in it an individual

* The life of an astronomer is severe, laborious, and confined.—If he does what he ought, adieu to the pleasures of the world. If he does not find his pleasure in his employment, adieu to astronomy. He should have ardour, activity, enthusiasm, and a real passion for becoming a good astronomer.

† There is still another fault sometimes committed, in requiring courses of lectures of astronomers attached to great observatories. I know some, who are obliged to labour in this way, and who are almost entirely taken up in giving instruction even in arithmetic and geometry, which wears them out. The Flamsteads, the Bradleys, the Maskelynes, the Schröeters, the Cassinis, the Maraldis, the Herschels, &c. were not thus encumbered with the business of teaching, and it ought always to be dispensed with.

of each class, the one for the science of astronomy, and the other for the business of observing; it is only by the union of both that an observatory, well furnished, can be properly conducted. * * * * * * *

* * * * * * There are persons, who doubt whether astronomical observatories are still necessary and useful. There are indeed those who go further, and question the utility of all the sciences, imagining that they have found in them the principal source of the innumerable evils that afflict mankind in the civilized state.

We do not pretend that science and virtue are inseparable, or that ignorance and happiness are never seen united. The unlettered man, like the philosopher, may enjoy the real substantial blessings of life, arising from a quiet conscience, a union of hearts, and the exercise of all the social virtues. This is the wise ordination of Heaven, to the end that each may have his share of the happiness which is provided equally, for all. But to infer from this, that science does not contribute to the good of man, that it is even worse than useless, is to outrage human reason, and to blame the author of nature, who amid all his works and all his creatures, has been pleased to endue man alone with intelligence, with a capacity for endless improvement, with powers that manifest themselves in him from the tenderest age, and which cannot be placed there without a purpose.

Man would inquire into every thing, know every thing, comprehend every thing. It is his instinct, it is the first workings of reason, and precedes all reflection. He surveys all nature as his domain, he descends into the bowels of the earth, sounds the abyss of the ocean, bounds into the immensity of the heavens, seeks truth every where, and allows himself no rest until he has penetrated into her sanctuary. Why are there beings who, disowning the voice of nature, would frustrate her designs? But they are notwithstanding nature's hidden powers, acting upon the moral, as well as upon the physical world; for these insane persons, who, relying upon their own vagaries to arrest the goings forth of the immortal mind, only accelerate its progress, as is manifest from the history of all ages and all nations.

Ignorance always brings with it a crowd of errors, as its natural offspring, and a host of prejudices to which it gives its sanction; these errors and prejudices, are always hostile to the good of man.

Science on the contrary, enriches the mind with new truths, overthrows ancient errors, and dissipates the fatal preju-

dices that beset it; such is the empire of science, which no where manifests itself so sensibly, and with such effect, as in the study of nature.

It is to a want of an acquaintance with the laws of nature, that we are to look for the origin of that superstition, which has deluged with blood all parts of the earth. It is to this source that we are to trace that awful delirium, in which man, from religious motives has waged war against his fellow man, on account of his opinions. It is hence, also, that have sprung all those absurd and whimsical rites, by which man has been debased, all those political and religious sects, so ridiculous, and at the same time so vicious, which have immolated their victims, sacrificed virtue, innocence, probity, and even modesty, by which man has been led astray, and made to commit the greatest moral, religious, and political enormities.

It is to a knowledge of the true laws of nature, moral and physical, that man owes the inestimable blessing, of having escaped the odious thraldom of fanaticism. It is an acquaintance with nature which has saved us from that melancholy and cruel superstition which has caused so much blood; it is this knowledge which has dissipated the darkness and the illusion of false opinions, so injurious to the peace and best interests of man. It is by observing the laws of nature, that man has arisen above those puerile fears, which so long overawed and subjected him. Eclipses, comets, the aurora borealis, meteors, &c. &c. are no longer regarded as inauspicious, or even marvellous, and well informed persons now view them with a tranquil eye and without apprehension. They are taught, or rather they teach themselves, to see nothing in the universe, but a supreme intelligence, infinitely wise and powerful, and physical and moral causes, always acting, and of which the action, regular and unchangeable, and incapable of being arrested or anticipated by man, has in it nothing to terrify or to disquiet. It is by studying nature in her greatness, that every thing is at length perceived to be governed with admirable wisdom, and immutable order, that constant laws are found to watch over the preservation of the universe, and that if certain causes tend to disturb this harmony, others also, all active, all powerful, are exerted unremittingly to preserve it. The agitation and oscillation which thus takes place, is only a return to a better state accidentally or necessarily interrupted. These extraordinary changes are as natural, and as necessary, as those which are more common and regular. They are exhibited to us in the heavens every day; they

are made known to us on the earth, in the history of all people. It is in vain therefore that ignorant, foolish man, should contend against this sovereign power of nature. It is safest to make no resistance, to yield to its force, and to follow the current with wisdom and moderation. The times are passed (and it is to be hoped never to return,) when eclipses, the smoking entrails of victims, the irregular flight of birds, the pecking of fowls, the divinations, the charms, the illusions, &c. &c. decided the fate of men and nations. The more man is enlightened, the further he extends his knowledge into the constitution of the world, and its laws, the more nearly he approaches to his true destiny and consequently to his true happiness.

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Art. LVI.—*Sketches of the Progress of Inventions, connected with Navigable Canals. Compiled from various sources.* [T.]

The triumphant progress of the Great Western Canal, begun a few years since, by the state of New-York, has fixed the attention of the public to works of this kind, in a degree, perhaps, unprecedented in any other country. In every district of the United States, canals are projected, and such are the supplies of water, and so favourable are other circumstances, that very few of the projects appear either chimerical, or, at least so far as the public is concerned, useless.

This advantageous mode of intercourse and traffic, is in some of its most important parts, of modern invention; although some of the canals of the ancients were designed for commercial intercourse, and on all it might have been practised in a degree; yet, irrigating and draining the land were the ends proposed by most of the canals, known in the early ages. The limit which the state of knowledge fixed to all works of this kind will be fully perceived, when it is recollected that locks, and consequently, different levels, were unknown until within a few centuries. The ancient canals, therefore, were no more than artificial rivers, which could be made only through countries nearly level, and which, in cases of deviation from that direction, not only presented the obstacle of rapids to the passage of boats, but required constant attention and labour, to preserve the embankments from

destruction, and perhaps, the neighbouring country from inundation. Such were the canals of India, Egypt, and ancient Italy, and such, at this day, are the canals of China. Notwithstanding however, the imperfection of these works, from the want of knowledge; some of them were formed on that scale of grandeur which so strongly characterizes the productions of ancient art. There seems to be good authority for believing, that the Red Sea was once united to the Nile, by a canal. One entrance of this canal is said to be yet remaining. The canal of Alexandria, which united that city with the Nile, still exists, although in a ruinous state. Formerly, the productions of Egypt were carried through this channel to Alexandria, thus avoiding the dangerous navigation of the mouth of the Nile, from whence they were shipped to Europe. The whole number of canals in Egypt, is said to have amounted to eighty, some of which were forty leagues in length and in some places nearly three hundred yards in width. The Greeks have left no great works of this kind; at least none for the purposes of navigation. A cut through the isthmus of Corinth, which would make a navigable passage from the Ionian Sea to the Archipelago, though often proposed was never effected. The canals of ancient Italy were neither numerous nor extensive. They were designed for the double purpose of drains and navigation. Such were the canals of the Pontine marshes, and those in the neighbourhood of the Po. In England, however, a Roman work, now called the Caerdike, formerly united the Nyne, near Peterborough, to the Witham, below Lincoln. It was nearly forty miles in length, and from the ruins, which still remain, must have been very broad and deep. Another canal, supposed to have been a Roman work, is still navigable, and connects Lincoln with the Trent, above Gainsborough, by one level of eleven miles. These canals are both situated in the English Fens, and are of course, natural levels.*

It has been observed, that locks were unknown to the ancients; they are still unknown to the Chinese. Some of the canals of China, however, are constructed on different levels, and their method of passing boats from one level to another is worthy of attention. The levels are connected by inclined planes, constructed of hewn stone.† These inclined

* For a particular account of ancient canals, see Phillips' General History of Inland Navigation, and Edinburgh Encyclopedia, art. Navigation, Inland.

† Journey of Louis le Comte.

planes, in some instances, connect levels differing fifteen feet in elevation. In passing from the upper to the lower canal, the boat is raised out of the water and launched over the inclined plane, the last part of the operation, of course, requiring no great labour, as the friction over the plane retards the descent of the boat. But in passing from the inferior to the superior canal, powerful engines are required. These consist of capstans from which ropes are passed round the stern of the boat. The effort of an hundred men is sometimes required to effect the elevation of a loaded boat. The objection to this mode, taken in this simple and rude form, lies not only in the great labour required by it, but in the injury which must necessarily be done to the boats. The practice could never be adopted with the slightly timbered barges used in our canals, which are calculated to be supported by the fluid in which they move, and which presses with a force perfectly equal on every part with which it is in contact. There are some situations, however, where, from a scarcity of water, the inclined plane is necessarily substituted for the lock. Some works of this kind, are used on the continent of Europe; and in England, in some cases, where the weight of the descending, greatly exceeds that of the ascending commodities, as in the traffic between mines and furnaces, inclined planes are used with advantage. In these situations the descending and loaded boat, is made to drag up an ascending one, which is empty, or but lightly loaded, thus exhausting in a useful purpose, a force which not being expended in friction, as rollers or wheels are used between the boat and the plane, could not be otherwise controuled without some labour and cost.

In enumerating the improvements in canal navigation, we shall commence with the lock. The period when locks were invented does not now seem to be precisely known. On this subject, the writers in the Edinburgh Encyclopædia say, "We have been at some pains to trace the original discoverers of this important engine; and though our researches have not yet been attended with all the success we could wish, yet we have been enabled to acquire some new lights respecting the early history of an invention, which three centuries, perhaps four centuries, have not yet brought to its ultimate perfection. Belidor, in his *Architecture Hydraulique*, supposes the invention to belong to the Dutch, from some expressions used by Stevinus, an eminent engineer of that country, in his treatise *Sur la nouvelle Maniere de Fortification par Ecluses*, published in 1634; but that superficial inquirer does

not seem to have comprehended the particular invention which Stevinus describes, who expressly says, that locks of the modern construction, a figure and very correct explanation of one which he gives, had been known in Holland from early times. His object was to describe a new kind of sea lock then lately invented, for the purpose of securing the harbours, and which might at the same time admit the passage of masted vessels. The difficulty was, to form gates which could be opened when the water on their two sides was at different levels. The inventions of several engineers there mentioned are described, and the preference given to the plan of turning gates, placed so as to fill up the frame of the common gates, and which, when let go, fall into the line of the stream.

"Stevinus first gives an account of the common mode of effecting the first object, as had been in use for a long time, viz. the raising a common sluice door by a windlass, which he says, does not allow the passage of masted vessels.

"2. He describes the sluices used for draining low lands, consisting of two doors, butting against the tide and shutting of themselves, which, he says are more useful than raising the sluices, because they admit of being larger, and require no attention to watch the tide; but he says they are also defective in not admitting masted vessels when they are placed under the dyke, and in not retaining water to scour the channel.

"3. The third kind of sluices, serving to pass masted vessels, are made with two pair of pointed doors, like the second, but raised as high as the dykes themselves, comprising between them a receptacle for ships, with two small sluices made in the walls, or in the doors themselves. Then he describes briefly the mode of passing a ship through the locks.

"Besides these, he says others have been made which open of themselves, with the ebb falling on the bed, and rise with the flood; also gates which are drawn aside into the land, but their use is not convenient.

"Stevin also informs us, that he and several other engineers had agreed to study this subject, and communicate their inventions to each other. The following was the result:

"Adrian Janssen, carpenter of Rotterdam, invented the locket for holding a turning gate in its place. A turning gate had been made at Briel, which was retained in a groove at the bottom, out of which it was wound three inches by a rack, ere it could turn into the line of the stream.

"Stevin's mode was to have rising vanes the whole width of each butting lock-gate; Cornelius Dirricksen Muys of Delft,

to have second lock-gates holding up the first; and Adrian Dirricksen of Delft improved Janssen's mode, by applying them in folding gates. He got a patent for it from the state, and built two at Maeslandsluis and two at Helvoetsluis of that kind, which yet exist. Stevin's whole account of this mode of securing harbours is well worthy of attention.

"Of the Italian authors, the first who enters into the history of the discovery is Zendrini, in his treatise *Della Acque Corrente*, published in Venice, 1746, who says, that being interested in ascertaining the original inventors of locks, he had taken some pains to search the Venetian annals on the subject, and found that the first lock was invented at Stra, near Viterbo, by two brothers of the name Dominico, clock-makers, in Viterbo, who had a patent for its construction from the senate of Venice, in the year 1481. The patent describes, that these engineers had engaged to construct a sluice, (concha,) in which boats might pass without danger, and which being so contrived, that the water passing out with facility, the vessels would neither be required to be discharged nor drawn over. This account has been acquiesced in by Lalande and other writers; but Lecchi, in his book *Dei Cannali Navigabili*, alleges that, previous to this period, in 1420, the lock had already been introduced in the navigation of Milan, by Fillippo Maria Visconti, as mentioned in his life, by Decembrio, one of his courtiers. And in 1188, Petentino, the architect of Mantua, had thought of it on his dykes on the Mincio, at Governolo, the first attempt at overcoming the fall of rivers in all Italy; so that Lecchi claims it for Lombardy. Nevertheless, there is every reason to believe that these cases were nothing more than the wear and single flood-gates already used for the navigation of rivers; for Bertazzolo, in his discourse upon the sluice of Governolo, published at Mantua in 1609, proposes a lock with a chamber, (sostegno,) to be built at the sluice of Governolo, as a new thing. This lock has since been established on the left bank of the Mincio; and, connected with an opening wear, it serves to hinder the turbid waters of the Po from filling up the lower lake of Mantua, while at the same time it preserves the navigation. Indeed, in many parts of Lombardy, wears with flood-gates are yet employed for river navigation, although locks exist of an early date, and some of them also of singular magnitude and boldness. To conclude, we may observe, that at all events, a very few years after the supposed invention

in the Venetian state, the celebrated painter, architect, and engineer, Leonardo da Vinci, in 1497, applied locks to connect the Milanese canals derived from the Adda and the Tesino.

"We must next consider the claims of Holland, that other great cradle of the hydraulic art of Europe. We have formerly noticed, that the embankment of the different districts of Holland had chiefly taken place between the years 1000 and 1400. In 1253, a placart was granted by William, Earl of Holland, to the city of Haerlem for the construction of the sluices of Sparendam. Those sluices must have necessarily been a lock; for it is expressly said to be constructed for the more convenient passage of ships, and a toll is appointed to be collected on the vessels which make use of it.

"About the same time, viz. 1255, the jurisdiction of Deftland, was established, and the ancient canal from thence to Leyden completed. On this canal, at the separation between Deftland and Rhineland, is the basin of Leidsendam, which as we have already observed, becomes, to all intents and purposes, a complete lock, by means of the stop-gates belonging to the two jurisdictions at either end, and it has always been used as such.

"At the same period, the citizens of Utrecht had formed an aqueduct from the river Lech at Vreeswyck; and in 1371, as we are informed by Hada, in the History of Utrecht, they deepened and enlarged this acqueduct, so as to make it navigable, and placed at the bank of the river Lech double flood-gates, or stop-gates of timber, by which the waters might be more easily kept out or introduced. (Hedæ *Hist. Epist. Ultraj.* Arnold. ii. *Episc.*) The structure was certainly a lock, as we see by a note upon the passage, describing an improvement which was made within the same century by the addition of a third gate, thereby converting it into a double lock. From this note, it is evident that the original structure permitted the passage of vessels, which William only renderer more secure during the high floods of the lock, by the construction of the third gate on the side next that river, thereby forming two chambers instead of one; and by the care that is taken to mention the name of this artist, it appears that the original or single lock was not considered as any new invention. There is therefore strong reason to believe that in Holland the lock was known, and in use at least a century before its application in Italy."

The construction of locks is not yet, perhaps, brought to that degree of perfection of which it is susceptible. An easy

passage for the boats, durability, and the least possible expense of water, seem to be the principal ends to be had in view in forming locks. Some of the locks on the most celebrated canals, built a century or two ago, are very deficient in some of these particulars. Such, for example, are those on the canal of Languedoc, that noble work which unites the Atlantic to the Mediterranean. These locks are oval, or in some instances of a circular shape, in the plan, forms adopted from a false idea that the pressure of the earth behind the walls would thrust them inwards. The consequence of this form, is that a large quantity of water is lost on the passage of every boat. The effect of the earth to overthrow walls built straight on the horizontal line, has been proved by the permanence of subsequent works, built in this manner, of no great amount, when they are otherwise properly constructed. The walls should always be built of masonry, if indeed iron should not eventually be introduced. The profile or figure given to the lock, as represented by a cross section, is of great importance, as on this the stability of the walls, in a great measure, depends. The walls should retreat or batter, as they rise, the batter being more considerable at the bottom and decreasing as the walls ascend; at their summit they become nearly vertical. An inverted arch, sprung from the bottom of each wall, gives them an admirable support, preventing them from sliding inwards, and against this it is necessary to have some guard.

There is a great variety in the size of locks, as the canal is navigated by large or small boats. The sea lock, near Inverness, on the Caledonian canal, is 180 feet long, 40 feet wide, and 20 feet deep, besides the lift, or difference of the levels, of 8 feet. The locks on the Derby canal, are 90 feet long, 15 feet wide, and 11 feet deep, including the lift of 8 feet. Those on the Leeds and Liverpool canal, are 70 feet long, 15 feet wide, with 9 feet lifts. In passing a lock, every ascending boat requires a quantity of water just sufficient to fill the lock from one level to the other, together with a quantity equal to the weight of the boat. But a descending boat expels a quantity of water into the upper canal as it enters the lock, which is retained by the upper gates; equal to the weight of the boat and its lading. To make a double passage then, or for two boats equally loaded to pass in opposite directions, it requires a quantity of water equal to the area of the lock multiplied by double the lift. This may perhaps, be taken without any great error, on locks of me-

dium size, at 320 tons.* A necessary precaution in fixing the site of locks, is to avoid placing them too near together, for in such case, the water let out of the upper lock on the passage of a boat, will overflow the banks of the subjacent level and not only be lost, but be likely to injure the works. The locks should be all of equal height, so that the water used at

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* In a memoir on navigable canals, by M. Girard, in the "Annales de Chimie," and which Mr Doolittle has translated and published in Silliman's Journal, vol. 4. p. 102, the expense of water by locks, is examined at some length, as follows:—"Does there not exist a necessary relation between the fall, the quantity of water expended for the passage of boats, and the draught of water of the boats which ascend or descend through the locks? This is a question, which, notwithstanding its importance, has never yet been treated, and which I propose to resolve. To reduce the question to its most simple expression, we shall suppose: 1st. That the boat is to pass from one level to another, by a single lock. 2d. That the boats are of a prismatic form, and that their dimensions are such that the interval which separates their sides from the sides of the lock, when compared with the space occupied by the boat may be neglected without sensible error.

"Let S, represent the horizontal section of the lock and the boat; $x$, the lift of the lock, that is, the difference of level between the two basins which it unites; $t'$, the draught of water of a boat which ascends the lock; $t''$, the draught of water of a boat which descends.

"The manœuvre of passing a boat from a lower to a higher level, consists in first drawing the boat into the lock through the lower gate, which is closed when the boat is in; 2d. Introducing, by no matter what means, from the higher basin into the lock, a quantity of water sufficient to bring the two surfaces to the same level; 3d. Opening the upper gate of the lock, and passing the boat through into the upper basin. Hence we see that to effect this passage and in order to raise the surface of the water in the lock to a level with that in the upper basin, it is necessary to draw from that basin a prism of water $= Sx$, whose base is equal to the horizontal section of the lock, and whose height is represented by the lift of the lock. Furthermore, when the boat passes from the lock into the basin, its place in the lock is necessarily supplied with a quantity of water $= St'$, equal to the volume of water which it displaces, and which flows from the basin into the lock.

"Thus the quantity of water expended in bringing things to their present state may be expressed by $Sx + St'$. Let us suppose that, the communication remaining open between the upper

the upper lock, or an equal quantity, may serve for the passage of the boats through the lower lifts.

A great many contrivances have been proposed either as improvements of the common lock, or a substitute for it. If in a lock of the common construction, we consider the water which is let down from one level to another, in the light of a force expended to produce a given effect, which is, the eleva-

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basin and the lock, another boat is ready to descend, the manœuvre is reduced to 1st. introducing the boat into the lock and shutting the upper gate; 2d. emptying the lock until its surface is on a level with that of the lower basin, and 3d. opening the lower gate and passing the boat into the lower basin.

"The introduction of the boat from the upper basin into the lock has caused a reflux from the lock into that basin of a volume of water $= St''$, equal to that displaced by the boat. In letting off the water from the lock, to lower its surface to a level with that of the lower basin, things are replaced in the same state as they were before the ascent of the first boat.

"This operation, which we shall denominate *a double passage*, has caused an expenditure of water represented by

$$Sx - S(t'' - t') = Sy$$

since the quantity of water expended may always be represented by a prism, whose base is equal to the horizontal section of the lock, and whose height is represented by an indeterminate line $y$. Dividing this equation by the factor S, common to all its terms, it becomes

$$y = x - (t'' - t');$$

which belongs to a right line of simple construction. It expresses moreover, between the lift of the lock, the draught of water of the boat, and the quantity of water expended, relations which, notwithstanding their extreme simplicity have not hither to been remarked.

"It follows from this equation that the expense of water, $y$, will be positive, null, or negative, according as we have:

$$x > t'' - t'$$
$$x = t'' - t'$$
$$x < t'' - t'$$

Thus it appears that the expense of water from any level may not only be diminished at pleasure, but that it may be rendered null, and that a certain quantity of water may even be raised from a lower to an upper contiguous basin."

There is, perhaps, no instance on any canal, where $x < t'' - t'$, or even where $x = t'' - t'$. Still, however, the investigation may be extremely useful as showing the relations which exist between the loads which pass through the canal, the lift of the locks, and the expense of water.

tion or depression of the boat and its load, there is a loss of the acting force unknown in any other mechanical operation. Thus, to raise a boat and load weighing 30 tons through 8 feet, it will in general require 180 tons of water, falling through an equal space. But in descending boats the effect is *negative*, and the disparity between this and the force is yet more striking. If, therefore, in transferring boats from one level to another, the economy of force only were considered, the inclined plane, arranged as it is in England, must be very advantageous, the expense of force being in theory, merely the small sum required to overcome the friction of the machinery and the inertia of the moving masses.

Mr Fulton, who paid much attention to this subject in the early part of his life, says, "I do not hesitate to prognosticate the annihilation of lock canals by improved science, in like manner as improvements in machinery renders the old apparatus useless." (Fulton on Canals, p. 28.) A bold prediction, which seems yet very far from being fulfilled. This gentleman was then highly in favour of the inclined plane as a substitute not only for locks, but for aqueducts. In his work published in London in 1796, he has detailed fully his plans. His machinery, besides the inclined plane, may be described in general terms, as consisting of an endless chain running over wheels, fixed, one at the top and one at the bottom of the plane; to this chain are to be attached two boats, in such a manner that the descending boat assists in dragging up the ascending one. The small force which may be necessary to pass the boats so arranged, over the plane, is to be supplied by a vessel of water descending through a shaft from the upper canal. The boats are to be small, and they are to be provided with wheels, to diminish the friction, in passing over the planes. Various other modifications of the inclined plane have been proposed; some of which, as has been before observed, are advantageously used in peculiar situations. None of them, however, are thought, at the present time, likely to become a general substitute for the lock.

Another contrivance, called the balance lock, consists in floating the boat into a case or vessel, at the termination of one canal, and moving it vertically, by machinery, to the other canal. There are two of these cases suspended over the same pullies or axle, so that they at all times balance each other, and that, whether one or both contain boats, because they are so executed that a boat on entering, expels from the case a quantity of water equal to its own

weight, and the same quantity returns to the case when the boat is passed out. But one of the most ingenious machines which has been invented to avoid the loss of water, is described in the Repertory of Arts, vol. 1, p 81, 1st series. It may, perhaps, be considered as a modification of balance locks, previously invented; still it exhibits great originality and inventive power in its authors. It is necessary in this, as in other balance locks, that the two canals terminate in the same vertical plane; the end of the upper canal being closed by gates at its termination. Things being in this state a well or pit is sunk at the head of the lower canal, of a depth somewhat exceeding the difference of elevation between the two levels. This pit is filled with water, and a diving chest or buoy, sufficiently strong to bear a heavy external pressure, is then made and put afloat over the pit. On the top of this chest several strong posts are erected, high enough to reach the bottom of the upper canal. These posts support a cradle, which is open above and nearly filled with water, and having gates at both ends, through which the boat may pass in and out. The specific gravity of the buoy must be so much less than that of its surrounding water, as to be just able to support the load, consisting of the pillars and cradle, which are fixed to it, together with the canal boat and a sufficient quantity of water to keep it afloat in the cradle. When so loaded, it should be just covered by the water in the pit, where it can now move up and down, on the application of a very small force, like the balloon or the Cartesian Devil. To let down a boat from the upper level, the end of the cradle is fixed by screws to the gateway of the canal, the gates of which, as also those of the cradle at the end next to the boat, are then opened; the boat enters from the canal into the cradle, displacing a quantity of water just equal to its weight, consequently the burden on the buoy is not altered. All the gates are then closed and the fastenings, which confined the cradle to the gateway, taken off; when on the application of a trifling force to the mass, the buoy descends to the bottom of the pit, bringing the boat to the plane of the lower level. The gates in the end of the cradle are then opened, and the boat passing out, its place is supplied by water from the lower canal.

There is yet another contrivance (Rep.vol. 2. p 235,) differing considerably from the above, although of the same class. It is a caisson or diving-trunk, made so as to be perfectly tight when the gates at its ends are closed. This floats in the lock between the two canals. The canal boat is received into it,

and it is made to descend, through the water of the lock, to the plane of the lower canal; when by opening the end of the caisson, and corresponding gates in the lower part of the wall of the lock; the boat is passed out. The ascending motion is obtained by pumping water out of the caisson, which operation is reversed to obtain a descent. In this and the preceding invention, the manner of passing an ascending boat will be understood, from the operation of descending, which has been described.

In another and distinct class of contrivances, it is proposed to fill the common lock by elevating water from a sort of cistern, made near it. To accomplish this, different kinds of plungers are to be used, some of which are very ingenious, particularly those of Betancourt*, Steevens†, Busby‡, and Bogaerts§. In these the plungers are so counterbalanced as to be always in equilibrio with the water in the lock, at whatever height it may be; consequently the application of a very small force, destroying the equilibrium produces the rise or fall of the water as may be required.

Although some of the preceding machines have been erected on the large scale, and have given promise of success; they have not made their way to public confidence, and have in the end been generally abandoned. We have thought, however, that it might be useful to recapitulate some of the inventions connected with so important a subject: several of these show that their authors were well acquainted with the laws of fluids, and that they pursued their designs with sufficient ardour to have conquered any small difficulties.

We have omitted mentioning before, an ancient and very obvious method, because it has been often used and found to answer its design, and has lately appeared in a new form and is said to be now in operation on the Regent's canal‖. There is an account in Belidor's *Architecture Hydraulique*, of a lock, constructed by M. Dubie in 1643, on the canal of Ypres, on this principle, where the lift was 20 feet. In this, two reservoirs were formed, one on each side of the lock with which they communicated, but on levels differing from

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* Repertory of Arts, Vol. 23, p. 125.
† Rep. Vol. 23, p. 147.
‡ Rep. Vol. 23, p. 1.
§ Newton's Journal, Vol. 1, p. 1.
‖ Washington Quarterly Journal.

each other: both of them however, being between the levels of the canal. When the lock was full and it was required to empty it for the descent of the boat; one third of the water of the lock was let off into the upper reservoir; another third was then let off to the lower reservoir; the remaining third, having an elevation but little above the lower canal, was then let into it, and the boat passed out. Now in these operations, supposing the reservoirs of such extent that the water let into them would not sensibly elevate their surfaces; two thirds of the water which filled the lock is still retained, at more than two thirds of its former elevation, and it may be again applied to fill the two inferior thirds of the lock: this was done in the canal above described, and the whole quantity of water required from the upper canal, to pass a boat, is said to have been but six feet. It is evident that if the water be divided among a great many reservoirs, all on different elevations, the water of the locks may be saved to a yet greater extent.

Several locks with reservoirs resembling the above have been constructed in England. The form used on the Regent's canal, to which we have alluded, consists of two locks placed beside each other. One of these being filled, and the other empty, and two boats ready to pass in different courses, the water is permitted to run from the full lock into the empty one, which it fills half full; the remainder is then supplied from the summit, and the boat elevated to the upper canal, while the boat, and the remaining water in the other lock, is let off as in ordinary cases.

(To be continued.)

## Art. LVII.—*Account of an Apparatus for determining the mean temperature and the mean atmospherical pressure for any period.* By John Farrar, Prof. of Mathematics and Natural Philosophy at Harvard University.

In a former number of the Boston Journal, mention is made of a clock being so constructed, with a variable pen-

dulum depending upon the temperature, as to answer the purposes of a thermometer. The following is a description of a pendulum, contrived upon this principle, which I had attached to a common eight-day clock, four or five years ago, and which is found to indicate the temperature in the manner proposed. It consists of a cylindrical glass tube A B, about thirty-two inches long and two inches in diameter, having at its upper extremity a large bulb C D, flattened at the top, about three inches in height and four inches in diameter, and communicating with the lower end of the cylinder A B, by means of the small tube *a b*. Thus constructed, the pendulum is to be inverted, and the bulb C D, together with the small tube *a b*, to be filled with mercury, well purified and freed from air-bubbles. The end B, of the large cylinder is then to be closed, so as to confine the air in the space between A and B, but at the same time allowing the mercury, the pendulum being again inverted, to descend into this space from the bulb C D, through the open end *b*, of the small tube *a b*. Thus prepared, the length of the column of air A B determines the length of the pendulum. As this contracts by cold, more mercury descends from the bulb C D, and the pendulum is lengthened; as it expands by heat, it throws more mercury up into the bulb, and in this way raises the centre of oscillation, and increases the rate of going of the clock. A column of air of 28 inches, (the distance between the surface of the mercury and A, at the temperature of 55°) ought to be subject to a variation from extreme heat to extreme cold*, in this climate, of seven inches, no allowance being made for condensation. The actual variation in the length of the column A B, produced by a change of temperature from 0° to 90°, has not exceeded two and a half inches; but this is found sufficient to cause a difference of about one hour in a day, in the rate of going of the clock. The whole apparatus, for example, being attached to the clock, at such a distance from the centre of suspension as to beat seconds, mean solar time, when the thermometer stands at 0°, the


* The range of the thermometer in this place, as actually observed, is no less than 119°. On the 4th of July 1811, it rose, in the shade, to 101°, and Feb. 15th 1817, it fell to 18° below zero.

clock will gain an hour a day when the thermometer stands at 90°.

In order that this clock may be made to answer the purposes of a thermometer, it must be ascertained by actual trial, what rate of going of the clock corresponds to each degree of the thermometer, from extreme cold to extreme heat. This may be done by placing the clock during a period of extreme cold, in a room communicating with one in which a fire is kept, and which may thus be heated to any required point, and kept stationary at this point for one hour, or a longer time, as may be thought necessary. The hourly gain or loss for each required degree being thus determined, if we multiply the several results by 24, we shall have the daily gain or loss answering to the different degrees of the thermometrical scale. By means of a table constructed in this manner, it will be easy to find the temperature of each day, equivalent to a deduction from observations made every second. We have only to observe once in twenty-four hours the gain or loss of the clock in question, by comparing it with a common well regulated clock, or chronometer, and to see to what degree or point of the scale this gain or loss corresponds. We should accordingly be able to estimate the relative temperature of different places, or of the same place at different times, with more precision than the present method admits of.

It will be perceived that, since any variation of temperature is indicated by the the gain or loss of the clock, as determined by actual trial, no account need be taken of any irregularity arising from longer or shorter arcs of vibration, in consequence of an increase or diminution in the length of the pendulum, as this irregularity is combined with that which depends simply on the length of the pendulum. The variation, therefore, from an assumed rate of going, may be fairly ascribed to change of temperature. Now in the clock above described, the gain in 24 hours corresponding to a change of one degree in the thermometer, is at a mean forty seconds; it may consequently be presumed, that the rate of going of the clock would give a result within half a degree of that obtained by a continual observation of the thermometer; it would at least give results more proper to be compared with each other, than those derived from the method commonly employed. It would be very easy to make the pendulum still more sensible to a change of temperature, by increasing the capacity of the cylinder AB, or by connecting

it with a globe of air, placed near the axis of vibration, where the resistance of the external air would have less effect.

It is very obvious that the going of a clock may be made to indicate in a similar manner, the state of the barometer. If we perforate the cylinder AB, which has hitherto been supposed air tight, the instrument would evidently be converted into a barometer. But the greatest range of the barometer in this latitude being only about two inches, a cylinder of this size would not be sufficiently sensible. The subjoined figure represents the form of one that I have used, in which E, F, are two cylinders, each about three inches in diameter. The tube *e f*, is made thick and strong, with a bore of the size of a common barometer tube. The end *f*, descends nearly to the bottom of the cistern F, and allows the air to pass freely between it and the neck of the cistern.


A course of experimental results being obtained for this pendulum, as in the case of the thermometrical pendulum, they might be employed in the same way in registering the state of the barometer. Relying also, as in the former case, upon the actual rate of going of the clock, answering to each particular state of the barometer, the deviation of the pendulum from a perpendicular, each vibration, and the greater or less deviation at different times, would be of little moment. A correction, however, would be necessary for change of temperature, which might be determined in like manner by experiment.

*Cambridge, January* 14, 1824.

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## Art. LVIII.—*Description of four native species of the Genus* Cantharis. *By Thaddeus William Harris, M. D.*

(Communicated by the Author.)

Modern entomologists have restored the name of Cantharis to that genus of insects, the type of which is the *Cantharis* of commerce.

Of this genus there are several species, which are natives of the United States.* Three, of the four inhabiting New-England, and occasionally employed in medicine, have been frequently confounded under the general appellation of *potato-flies*, and have been incorrectly designated by a scientific name peculiar to one species only. Specific distinctions if not practically are scientifically important. A concise description of these four species will be given, by which they may be easily distinguished from each other, and a summary will be presented of such facts as have hitherto appeared respecting their history, and medical utility.

The insects of this genus deposit their eggs in the ground. The larvæ hatched from them have six legs, are soft-bodied, generally of a yellowish colour, and live upon various vegetable substances. When fully grown they change into the pupa, and, after a certain time, emerge from the earth in the perfect state. It is in this state, only, that they are furnished with wings, and are capable of propagating their species. The males are usually smaller than the females.

The natural family CANTHARIDÆ contains eleven genera, including several insects in which epispastic properties have been detected. Among them are found the celebrated blistering fly of the ancients, *Mylabris cichorei*, which at this day holds a distinguished place in the materia medica of the Chinese, and another species of *Mylabris*, plentiful in India, and said to be quite as efficacious as the common Spanish fly. The existence of similar qualities in *Meloë proscarabœus* has

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* Thomas Say, Esqr, of Philadelphia, a diligent and profound entomologist, informs me that the number of species, already discovered within the United States, is sixteen, viz.: *C. segmenta, Nuttallii, albida, articularis, immaculata, sphæricollis, maculata, ferruginea, reticulata, vittata, marginata, atrata, ænea, polita, cinerea*, and *Afzeliana.* A description of the nine first has been communicated, by Mr Say, to the Academy of Natural Sciences, and will appear in the Journal of the Academy; a work which has advanced the cause of Natural History, both at home and abroad; and which is greatly indebted to the labours and contributions of this gentleman.

Of these sixteen species the names of but five occur in the Systema Eleutheratorum of Fabricius; they are the four described in this paper, and *Lytta Afzeliana*, a native of Carolina. The remaining eleven are, probably, newly discovered insects; one only of which, *C. ænea*, is a native of Pennsylvania.

Mr Say observes that perhaps most, if not all, of these species might be used with success for the purpose of vesication. Some of them are larger than *C. vesicatoria;* and, among these, the finest, *C. Nuttallii*, a most brilliant insect, was once discovered in great quantities near the Rocky mountains.

been ascertained by some of our country physicians, and the fact is also noticed by Dr Bigelow, in his materia medica. Probably, many other insects in this family would be found useful in medicine; but those best known are *Cantharis vesicatoria*, and the species of the Fabrician genus *Lytta*, which are the subjects of this paper.

The following is the systematic arrangement and definition of the genus *Cantharis :*

Order Coleoptera.

Section 2d. Heteromera. Four anterior tarsi five-jointed, hinder pair four-jointed.

Family Cantharidæ. Latreille and Leach.

Head large, cordiform; neck distinct; mandibles not notched at their points: thorax almost quadrate, or cordiform: elytra flexible: tarsi generally with entire joints.

Stirps 3d. Antennæ longer than the thorax, composed of cylindric or obconic joints.

Genus Cantharis. Geoffroy, De Geer, Olivier, Lamarck, Latreille, and Leach. Meloë. Linné, Lytta. Fabricius.

Elytra soft, elongate, linear, with the sides somewhat inflexed, the back convex, rounded. Maxillæ with two membranaceous laciniæ, the external acute within, subuncinate. Antennæ with the first joint larger than the others; the second very short, transverse; the rest obconic; the last ovoid.

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## SPECIES I.—Cantharis vittata. *Striped Cantharis.*

Elytra black, with a yellow fillet and margin.

Head light red, with two vertical spots and the antennæ black: thorax black, with three yellow lines: elytra (or wing case) black, with a central longitudinal fillet and the whole margin yellow: abdomen and legs black, and covered with a cinereous down. Length six lines.

Inhabits North America: upon the Potato (*Solanum tuberosum*) eating and destroying the leaves.

As early as the year 1781 this American insect was described in Europe by Fabricius. It was not, however, brought into notice here until the accidental discovery of its medicinal properties by Dr Isaac Chapman, of Buck's county Pennsylvania. In 1797 he first employed it for the purpose of producing vesication, and published a description of it, with the results of his experiments, in the New-York Medical Re-

pository. From this account it appears that, in seven cases, he employed successively all parts of these insects with the same results; and he considers them more certain as vesicatories than the cantharides of the shops.

The medicinal reputation of this insect soon reached Europe. In Illiger's *Magazin*, printed at Brunswick; in 1801, is an account of this and the species to be next described; the substance of which is, that, in America, the Potato suffers much from two beetles, *Lytta cinerea* and *vittata* of Fabricius; that these extremely common and noxious insects have been substituted with great success for the costly *cantharides*, and are said to vesicate more speedily, and with less pain, at the same time that they cause no strangury. The latter part of this statement is incorrect; it having been satisfactorily ascertained that, when externally applied, they are capable of exciting strangury; and that the same effects follow from their internal exhibition.

Cantharis vittata is found in the southern and middle states, and in Connecticut; but is a rare insect in Massachusetts.

### AUTHORITIES AND SYNONYMS.

Cantharis vittata, Olivier, *Entomol. Vol. III.* (*Paris.* 1795.) *No. 46. Pl. I. fig.* 3.—Pallas. *Icon. Tab. E. fig.* 53.

Lytta vittata, Fabricius, *Spec. Insec.* (*Hamburg.* 1781.) *Vol. I. p.* 329. *n.* 6. *& Entomol. Systemat. Vol. I. Part* 2. *p.* 86. *n.* 11. *& Systema Eleuth. Vol. II. p.* 79. *n.* 18.—Gmelin, *Systema Naturæ. Vol. IV. p.* 2014.—Chapman, *New-York Med. Repos. Vol. II. Edit. 2d, p.* 163.—Illiger, *Magazin fur Insectenkunde* (*Brunsweig.* 1801.) *I.* 256.—Kirby & Spence, *Introduc. Entom. Vol. I. Edit. 3d, pp.* 188 *&* 317.—Gorham, *Med. Com. Mass. Med. Soc. 3d Series. pp.* 56, 57, 58.—Bigelow, *Treatise on Mat. Med. p.* 112.—Chapman, N. *Elements Therapeutics. Vol. II.*

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### SPECIES 2.—Cantharis cinerea. *Ash-coloured Cantharis.*

Body black, covered with a cinereous down.

All parts of the body and elytra are entirely covered with an ashen-coloured down, extremely short and dense, concealing beneath it the black colour of the insect. The antennæ are black; the first and second joints, in the male, very large: male less than the female: resembles C. vittata in figure and magnitude.

Inhabits North America; feeds on the leaves of the Potato, English Bean, (*Vicia faba*) and Indigo weed (*Podalyria tinctoria.*)

This species of Cantharis is to us by far the most important, from its greater abundance and constancy of appearance; from the long experience the faculty have had of its efficacy; and from its having been the subject of a communication made to the Medical Society of Massachusetts by Dr John Gorham, in 1808. From this interesting communication we learn that, for several years previous, Dr Israel Allen of Sterling, Massachusetts, had successfully used as a vesicatory an insect found upon the Potato vine. Dr Gorham obtained a quantity of these insects and, by extensive experiments, established the characters which had been given them.

Dr Gorham's experiments prove, that the powder, externally applied, produces a more speedy and thorough vesication and a more abundant purulent secretion than the powder of Cantharides; and with the same specific action on the urinary organs; and that the internal exhibition of the powder and tincture is attended with the same effects as those which result from the administration of Cantharides.

It was sufficiently apparent, from Dr Gorham's description, that the insect in question could not be the striped potato-fly, Cantharis *vittata**. Having applied to Dr Luther Allen of Sterling, the brother of the late Dr Israel Allen, for information on the subject, I was politely furnished by him with both recent and old specimens of the insect; from an examination of which I was enabled to ascertain the species; which proved to be Lytta cinerea, of Fabricius, whose epispastic properties, as before mentioned, had been described by Illiger, in 1801. I also procured, from a respected physician and friend in Worcester, a parcel containing blistering cantharides of the same species, which were collected for medical use in that place. The ash-coloured substance, which clothes the insect, like the down of the plum, is easily removed by attrition; and, in those which have been kept sometime, is scarcely visible, especially on the elytra.

Cantharis cinerea is common enough every year, in July and August, upon the English (Windsor) bean and the potato-vine. Its epispastic virtues have been known some years to an eminent physician in this vicinity, and, while with him, I had

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* *Vittata*, striped, from *vitta* a fillet or stripe.

an opportunity of testing them by experiment, before I had ascertained its identity with the fly described by Dr Gorham.

About the first of August the perfect insect buried itself in the ground, and there deposited its eggs: these were hatched by the first of September. The head of the young larva is reddish; the body yellow, with three transverse black bands. I have not, as yet, been able to trace the progress of the larva to its metamorphosis into the pupa, and perfect insect.

Dr L. Allen furnished the following facts.—These insects are not constant in their appearance; but few having been seen since 1806.

They prevail only in dry seasons, on the Potato-vine, English bean, and Indigo-weed.

They retire for shelter to the ground during the night; are taken in the morning from 8 to 10 o'clock, by shaking them into a pan of vinegar. Vinegar thus impregnated, vesicated the hide of a horse.

If suffered to remain on the skin any considerable time after vesication they produce a deep eschar, destroying not only the cuticle but the cutis vera.

AUTHORITIES AND SYNONYMS.

Cantharis Sericea, OLIVIER. *Entomol. Vol. III. No.* 46. *Pl.* 1. *fig.* 8.

Lytta cinerea, FABRICIUS. *Entomol. System. Supplement. p.* 119. *n.* 13.—*& Syst. Eleuth. Vol. II. p.* 80. *n.* 20.—ILLIGER, *Magazin. I.* 256.—KIRBY & SPENCE, *Introduc. to Entomol. Vol. I. p.* 188 *&* 317.

Potato Fly, GORHAM. *Med. Com. Mass. Med. Soc.* 3*d Series. p.* 59.

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SPECIES III.—CANTHARIS MARGINATA. *Bordered Cantharis.*

Black, with the margins of the elytra ash-coloured.

Head, thorax, and abdomen black, but nearly covered with an ash-coloured down: Elytra black, with the margin and suture ash-coloured: upper part of the abdomen, under the wings, marked with two longitudinal streaks of a bright clay-colour. Nearly double the size of C. vittata, and unlike it in figure. Male less than the female.

Inhabits North America upon the *Clematis*; and is also found in Africa, at the Cape of Good-Hope.

In 1799 Prof. Woodhouse, of Philadelphia, discovered this and the fourth species; and, having ascertained that they possessed vesicating powers, he made known this discovery to Dr Mitchell, by a letter, which was published in the third volume of the New York Medical Repository. The insect under consideration he proposed to call *Meloë clematidis**, from its being particularly fond of several species of this plant. Fabricius, however, had previously described it, as a native of the Cape of Good-Hope, by the name of *Lytta marginata*. Dr Barton says that this insect is one of the most active species of American blistering flies; and that it feeds upon the leaves of *Clematis crispa*, and *C. viorna*. This observation led me to look for it upon C. virginiana, which grows in profusion on the banks of the Neponset; nor was I disappointed in the search; for, about the first of August, when the vine was in flower, I procured enough of these insects to enable me to make trial of their powers, which proved to be fully equal to those of any species of cantharis, hitherto employed for vesication.

A few were found feeding upon the leaves of *Ranunculus bulbosus*, and not in the vicinity of the Clematis; they therefore are not confined exclusively to the latter plant.

They resort mostly to such branches of the Clematis as trail upon the ground; seldom frequent the superior parts of the vine; are very shy, and, when disturbed, fall immediately from the leaves, and attempt to conceal themselves in the grass. Other species of this genus manifest the same timidity.

## AUTHORITIES AND SYNONYMS.

Cantharis marginata, Olivier. *Entomol. Vol. III. n. 46. pl. I. fig. 2.*

Meloë cinereus, antennis elytrisque atris, margine cinereis, Forster. *Nov. Spec. Centuria. p.* 62. *n.* 62.

Lytta marginata, Fabricius. *Spec. Insect. Vol. I. p.* 329. *n.* 5.—*& Ent. Syst. Vol. I. part* 2. *p.* 85. *n.* 10.—*& Systema Eleuth. Vol. II. p.* 79. *n.* 16.—Gmelin. *Syst. Naturæ. Vol. IV. p.* 2014.—Barton. *Elements Botany. Part* 3. *p.* 70. (1803.)

Meloë clematidis, Woodhouse. *N. York Med. Repos. Vol. III. p.* 203.

* Pallas gave this name to another insect found by him in Siberia.

## SPECIES IV.—Cantharis atrata. *Black Cantharis.*

Entirely black, immaculate.

In general contour this species resembles C. marginata, but is not more than one-third as large; the female also, as in that species, much exceeds the male in size.

Inhabits Barbary; and, in North America, on the *Solidago.*

This, as before observed, was one of the native blistering flies described by Prof. Woodhouse in 1799. Melsheimer appears to be unacquainted with its vesicating properties, but alludes to those of the three former species of this genus.

This insect has received various names from different authors, and is described three several times, with as many distinct appellations, by Gmelin, in his edition of the Systema Naturæ. In Boston it is kept and sold for Cantharis vittata.

It is common every year on the golden-rod, *Solidago altissima,* sometimes on *Solidago lanceolata;* and, according to Prof. Woodhouse, on the Self-heal, *Prunella vulgaris,* and the stick-weed, *Ambrosia trifida.* Dr Thatcher informs me that it is found on the Potato-vine, in Plymouth county; from whence, I believe, the Boston apothecaries have been supplied. I have myself seen them, occasionally feeding on the Potato-vine.

This insect is the subject of a paper, in the New-England Journal of Medicine and Surgery, by Dr George Osgood, who employed it, both in tincture and substance, in more than forty cases, without failing to produce vesication in any instance. I have been satisfied with its efficacy as an epispastic, from experiments made with it. If further evidence be wanted in its favour, we have the strongest in its being substituted, from ignorance of the species, for *C. vittata,* without having either its virtues or identity questioned.

It makes its appearance about the middle of August, when the *Solidago altissima* puts forth its blossoms, which are the favorite food of this species.

### AUTHORITIES AND SYNONYMS.

Cantharis atrata, Olivier. *Entomol. Vol. III. No.* 46. *Pl.* 2. *fig.* 19.

Lytta atrata, Fabricius. *Entomol. Systemat. Vol. I. part* 2. *p.* 86. *n.* 12.—*& System. Eleuth. Vol. II. p.* 79. *n.* 19.—Gmelin, *System. Naturæ Vol. IV. p.* 2014.—Melsheimer, *Catalogue* (1806) *n.* 1250.—Osgood, *New-Eng. Journal Med. & Surg. Vol. X. p.* 338.

Lytta pennsylvanica, Gmelin. *Syst. Naturæ. Vol. IV. p.* 2016.
Meloë pensylvanica, De Geer. *Memoires Vol. V. p.* 16. *n.* 1 *Pl.* 13. *fig.* 1.—Gmelin. *Syst. Nat. Vol. IV. p.* 2020.
Meloë nigra, Woodhouse. *New-York Med. Repos. Vol. III. p.* 203.—Chapman. *Elements of Therapeutics. Vol. II.*

Before concluding this paper, I would remark, that the white grain, which has been observed in the abdomen of these species of Cantharides, appears from an examination of the recent insect, to be composed of the abdominal viscera, spermatic vessels, and the ovaries. The eggs are very numerous, and nearly fill the body of the female. The fœcal matter is of the same colour as the food; yellow, from the blossoms of the golden-rod; and green, from the leaves of the potato, &c.

The blistering quality of these Cantharides probably depends upon a principle peculiar to themselves, the result of their organization, and not to be detected in the plants from which they draw their nourishment. The leaves of the potato, English bean, and Indigo-weed, and the flowers of the golden-rod may be rubbed, and worn on the skin, any length of time, without producing the least inflammation: And, although the leaves of *Clematis crispa* and *viorna*, and of *Ranunculus bulbosus* are extremely acrid and irritating, Cantharis marginata, which feeds upon them, is equally as fond of those of *Clematis virginiana*, which are quite inert.

*Milton, Jan.* 1, 1824.

# General Intelligence.

*Comet of* 1823, '24.*—The following observations of this comet, have been collected since the time of its first discovery in this country. They were principally taken by Mr W. C. Bond, of Dorchester, near Boston. The instrument

* For this account of the Comet we are indebted to Prof. Farrar.

used was a good sextant. The times were noted with great care, and with a well-regulated time-piece. The state of the barometer and thermometer was also registered for each set of observations. It would be superfluous, however, to have regard to the particular states of the atmosphere, in such observations, especially as the head of the comet was of so considerable an extent and so ill defined. The following are the means of from three or four, to eight or ten, observations for each star each evening. The times are *mean*, civil reckoning; and the distances unconnected for refraction.

| | | Gemma. | | Lyra. | |
|---|---|---|---|---|---|
| Dec. | 27, A. M. | 5h. 30′ | 29° 28′ 00″ | 5h. 20′ | 37° 48′ 00″ |
| | | Arcturus. | | | |
| | 29, A. M. | 5h. 07′ | 41° 27′ 36″ | 5h. 08′ | 35° 45′ 25″ |
| | 30, A. M. | 5h. 22′ | 40° 40′ 06″ | 5h. 30′ | 35° 53′ 08″ |
| Jan. | 4, A. M. | 5h. 17′ | 36° 51′ 12″ | 5h. 22′ | 30° 55′ 00″ |
| | 7, A. M. | 5h. 16′ | 34° 44′ 00″ | 5h. 07′ | 28° 32′ 30″ |
| | 9, A. M. | 4h. 14′ | 33° 38′ 34″ | 4h. 51′ | 27° 31′ 42″ |
| | 22, A. M. | 6h. 19′ | 41° 17′ 30″ | 6h. 16′ | 37° 47′ 30″ |
| | 27, A. M. | 5h. 29′ | 51° 36′ 00″ | 5h. 34′ | 50° 40′ 20″ |
| | 28, A. M. | 6h. 08′ | 54° 07′ 20″ | 6h. 07′ | 53° 27′ 32″ |

| | | Dubhe. | | Polaris. | |
|---|---|---|---|---|---|
| Jan. | 7, A. M. | 5h. 26′ | 67° 20′ 00″ | 5h. 44′ | 67° 35′ 20″ |
| | 9, A. M. | 4h. 20′ | 63° 58′ 26″ | 4h. 57′ | 64° 02′ 12″ |
| | | | | Beta Urs. Min. | |
| Jan. | 21, P. M. | 10h. 09′ | 30° 40′ 00″ | 10h. 07′ | 16° 21′ 00″ |
| | 23, P. M. | 9h. 37′ | 24° 39′ 40″ | 9h. 37′ | 10° 56′ 38″ |
| | 24, P. M. | 8h. 54′ | 21° 49′ 36″ | 9h. 04′ | 09° 00′ 00″ |
| | 27, P. M. | 7h. 30′ | 14° 10′ 20″ | 7h. 29′ | 09° 24′ 30″ |

It will be seen from the foregoing observations, that the comet, as viewed from the earth, has proceeded with an accelerated velocity. Its motion, when first observed, was a little more than a degree a day; about the 9th of January it amounted to two degrees, and during the latter part of its course, it exceeded three degrees. It reached the circle of perpetual apparition on the 18th, attained its greatest geocentric latitude, 70°, on the 22d, and had nearly arrived at its greatest declination on the 28th, the date of the last of the above observations. The whole track described from the 27th of December to the 28th of January, is about 77½ degrees. The greatest length of the tail was about 6 degrees.

We understand, that Mr E. Clapp is engaged in calculating the elements of the orbit of this comet, and that the public will probably soon be favoured with the result of his researches. It is much to be regretted, that we have not the means of furnishing more accurate data to proceed upon, the business of calculation would be so much abridged, and the results so much more to be relied on. A new object presents itself in the heavens, and we must wait for a vessel to cross the Atlantic before we can undertake to say precisely where and what it is. If the means provided in this country for cultivating the different branches of knowledge be contrasted with those of the old world, there will probably be found no deficiency so great and striking as the want of an astronomical observatory.

*Extinction of Fires in Chimnies.*—M. Cadet Vaux, reflecting on the circumstances of a fire, when it occurs in a chimney, was led to endeavour at its extinction, by rendering the air which passes up the flue, unable to support combustion. This object he obtained by the simple means of throwing flour sulphur on the fire in the grate, and so effectual was it, that a faggot suspended in the chimney, very near the top, and consequently near the external air, when set on fire, and burning with great fury, was instantly extinguished, on the application of the sulphur below. This process is the more applicable, inasmuch as it does not require that all the oxygen in the air should be converted into sulphurous acid gas, before it passes up the chimney; on the contrary, a comparatively small proportion of the latter gas, mixed with common air, is sufficient to prevent its supporting the combustion of common combustible bodies. *Jour. Roy. Ins.*

Cummings, Hilliard & Co. will shortly publish a new edition of Smellie's Philosophy of Natural History; with various alterations and additions, intended to adapt it to the present state of knowledge, by Dr Ware. To this edition is prefixed an introduction, which takes the place of the few first chapters of the original work, containing a general account of the nature and phenomena of animal and vegetable life, and a sketch of the classification of the animal kingdom, according to the most approved modern authorities. No further alterations have been made in this work than were necessary to fit it for the purpose for which it was intended, to serve as an introduction to the study of Natural History. The size of the present edition is something less than that of the original work.

**Art. LIX.**—*Description of Vettie's Giel, a scene in Bergen-Stift, in Norway.* By the Rev. U. F. Borgesen*. [*Edin. Phil. Jour.*]

I had often heard of this remarkable Giel†, the only passage to a farm, considerable especially for the number of cattle reared on it. From the danger and the difficulty of the way, no clergyman or other official person had ever visited it. What seems more remarkable, not even the oldest peasant in Farnæs (the nearest district to it) had ever been on the farm of Vettie. Men lived and died in close neighbourhood to it without having ever seen it. Nobody ever repaired thither but those who were the nearest relations of the family who lived on it, who of course were in the most isolated situation possible in an inhabited country. My curiosity was much excited. Besides, in order to have a more accurate knowledge of the people and the district, I had made a point to allow no corner of my parish to remain unvisited. The danger itself was a sort of allurement, as it was a triumph to surmount it.

On Sunday the 12th of June 1818, after divine service, I set out from my manse in Aardalannex, in company with a number of people who had been at church, to Aardal's Water. This lake is about three-quarters of a mile long (more than four English miles,) and at the broadest, half a quarter (about three-quarters of an English mile,) enclosed on both sides by lofty mountains, which, from their steep and sometimes perpendicularly hanging sides, forbid all approach by land. The lake is thus the only and the common communication between those who live above it and the other parts of the district of Aardal. There were many boats of us in company, the most of which strove with great exertion to row past one another. They are excellent rowers; and this passage to and from church never takes place without this sort of contest, the only object of which is the honor of winning. It is pleasant to witness this contest. Six men, commonly stout young fellows, sit at the

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* Read before the Wernerian Natural History Society, 31st May 1823.

† A *Giel*, in Norwegian, means a narrow glen with steep precipices on both sides, the space between filled up by a river. Vettie's Giel is several Norwegian miles in length.

oars; the boat darts forward like an arrow; and you may imagine the vigour which is exerted, when the blade of the oar sometimes snaps in the water,—a circumstance which happened to the boat that was striving with ours, and which, in consequence, fell a considerable way behind. But as they had got a reserve oar, which was put out in haste, our boat, which was deeply laden, having about twenty people in her, was quickly overtaken and passed. So soon as the boat you contend with falls a good way behind, or it is perceived that in spite of all exertion you are not able to keep up, the strife is over, though it ceases not without some sarcastic jokes on the part of the conquerors. After this, though they still push briskly forward, they go on more equally in company. We pushed on, and were immediately run on the beautiful Farnæs, where the river Utledal, which, by a course of six miles from where it rises in the mountains of Guldbrandsdal, runs through Utledal, Vettie's Giel, Svalemsdal, and Farnæs empties itself by seven mouths. It was already evening, and pretty dark; I therefore took up my night's quarters at the farm-house of Vee, a pretty large farm, which has an interesting situation on the south side of the river Utledal, not far from Farnæs. There my appointed guide was already waiting for me, a houseman (a sort of sub-tenant in Norway,) who was well acquainted with the family at Vettie. We set out on our road early in the morning, and as this was at first over fine even plains, we mounted on horseback. In the neighbourhood of Vee we passed a mighty water-fall, which, from a side dale called Rösdale, rushes down in one fall of 150 fathoms. Farther east is Valdersdal, so called, because in a stretch of 4 miles, (about 27 English,) it goes up to the mountains of Valders. Through this dale runs the river Thya, coming from the lake Thya, which here descends in a large fall, forming three cascades. Over its mouth is carried a bridge. A little farther on in the vale, on the other side of Utledal River, the course of which we follow the whole way, you see a rocky mountain called Möekamp, lying east and west, as if it were sunk between the far higher mountains on each side. Round the foot of this, lie a couple of farm-houses, and several housemen's places. From the River Thya you come on a very high sand-hill, under which lies the farm of Möe. When you have toiled up this difficult and very steep hill, you come to Sualem-hill, a little mountain ridge lying east and west, and consisting of entirely naked, slippery rocks, on which it is both difficult and dangerous to ride. You now come to the

fine plain land of Sualem, which, of considerable extent, stretches on to the farm of Jelde. You have here got about half a mile from Farnæs, and you begin to perceive that the Giel is near.

Nature now assumes a severer character; her smile totally vanishes; the dale contracts itself closer together; the black mountain masses tower higher up on both sides, casting abroad their melancholly shadows. Before you come to the farm-house of Jelde, you pass a bridge over the River Jelde, which, coming from a very high pasture-glen belonging to the farm, gushes down in a fall of about 200 fathoms. Every thing is gigantic and threatening. It is nature's grand style. Small objects disappear, and the heart beats with the anticipation of approaching danger. At Jelde, you do well to dismiss your horse, and trust to your own legs. It will now, too, be of importance to provide yourself with an additional guide. Farmer Civind offered to accompany me; but, as he could not himself go with me the whole way, he made his servant likewise be of the party. I had thus three companions well accustomed to this road, and therefore, on their own part, altogether unconcerned about dangers which were familiar to them, but who could very well enter into the feelings of a person in a different mode of life, who, for the first time, trod a path the like to which he had never seen, nor could conceive. When Civind had found his axe, which he had long to look about for, and the use and necessity of which I had afterwards to learn, to my terror, we all set out.

At a short distance from the dwelling-house of Jelde farm this frightful way begins. The entrance to the Giel is altogether worthy of it. You climb up over the hill of Jelde. This is a projecting out-corner of the mountain, consisting of granite, which, with an inward bend, hangs over the river which washes its foot. It is thus impossible to find a lower road, as this precipice forms the bank of the river. It is a severe exertion to climb this steep and difficult path at such a height, and constantly on the brink of precipices.

It is probably this hill which has fixed the height of the path in the Giel itself; for otherwise, you see no reason why it should have been cut out, at such a height, on the side of this frightful wall of rock, that the person who falls over it, must be dashed to pieces, before he reaches the surface of the water. When you have reached the top of this hill, you turn round to the right hand, and enter into the Giel itself, by a bridge of pliant trunks of trees, laid over with birch-bark, and turf and gravel, that all swing under your

feet. The mountain here hangs a little over the passenger's head, and you willingly incline to it as to a friendly support, to avoid seeing, and if possible, to avoid thinking of the abyss you are swinging over, but of which, the gravel thrown down by the motion of the bridge, is all the way putting you in mind. You are now in the Giel. Traveller, God be with you!

The path here is not broader than that a person can just stand on it with both feet beside each other. Sometimes you have only room for one foot; nay, at times, from the quantity of loose earth and small stones which you may well suppose are frequently tumbling down here, and covering the whole path, you find no place at all to stand on, but must, with your foot, in a manner scrape out such a place in these loose materials, which here lie over the surface of the whole precipice, the upper part of which forms a very sharp angle with your body, while the part below approaches frightfully near to a perpendicular line.

About half a quarter of a mile on in the Giel, on the north side of the river, high up towards the summit of the mountain, there opens on you, a cross valley, the remarkable Afdal. The houses on a farm which is here, stand on so steep a slope, that, while the under-beams rest with one end on the ground, to have a horizontal position, they must be supported on the opposite side, by a wall of 4 ells in height (8 feet English.) The fields too, lie so steep, and so near the frightful precipice, that no person unaccustomed to it, would venture to set a foot on them. And when, from the Giel, you see their grass fields, which hang rather than lie over the deep below, and which are every year mowed with a kind of scythe, wrought by one hand, you can scarcely conceive the desperate courage which coolly plies its task where an abyss seems open to swallow the fool-hardy man.

A little above the dwelling-house, is a piece of ground, tolerably flat; and when you inquire why they did not rather build there, you are told that it is impossible to build there, from the quantity of snow that tumbles down on it. Through this dale, runs the river Afdal, which rises from the summits of the mountains called the Young Harlots*. It

* These are reckoned among the highest mountains in Bergen-Stift, higher than Galetind, the height of which is given at 5514 feet above the sea. They take their name from a singular tradition in the country. A marriage party, who were all very wicked persons, on their way to church, were changed, by the wrath of Heaven, into these rocky summits. There are seven of them, of which the bride and bridegroom are the highest.

runs past the house, at a distance of about 30 ells; and at about 150 ells from it, with a noise like thunder, tumbles over the precipice in a tremendous fall. The violence of this, and the agitation produced by its rushing over, is such, especially in summer, that the house continually shakes; and every fluid which stands in an open vessel, exhibits a constant tremulous motion. The walls and the windows which are next the river, are always wet, from the vapour ascending from the fall. They told me, that this fall was 200 fathoms high; and when you look down to the abyss below, and then raise your eye to where the river issues from this lofty vale, you can scarcely call it in question. Beside the fall in the hard granite precipice which it washes, they have mined a rut, I cannot call it a way, though it serves for one, broad enough for one man; or, at most, a little well-trained horse, but not beside one another, to go upon it.

This rut, the roof of which is just so high, that a grown up person can stand upright in it, is the only way to the farm-house till you get up to a considerable height. It reaches not, however, the whole way. There is a gap, which is filled up by pieces of timber, joined together, of 6 or 7 ells in length, one end of which rests on this rut, the other on a projection of the mountain, which likewise serves as a support to a bridge which goes over the fall. In these pieces of timber are cut notches, which serve for steps; and in going up these notches, while you see through the timbers the foaming cataract under you, and are involved in its mists, he must be a native of Leirdal who does not then feel that his life hangs on a few inches of slender tree. It is a matter of course, that neither this wooden path nor the bridge itself, nor the rut in the side of the rock, are provided with any kind of rail or defence. A Leirdaller knows not the name, has not the conception of giddiness. He falls as other people do, although he stands where they would fall: he is dashed to pieces like them, but this comes from his inconceivable rashness, and from his not having wings. Of the ten years I have now been here, not one has passed without instances of persons being killed by falling over precipices. This is one of the common modes in which people die, and it awakens no particular sensation. They believe, however, that the spirits of these persons go about after death, and they have a particular name by which they distinguish them from other ghosts. When the farmer in Afdal brings any thing

to his house, when he comes to the river he must take it off the horse, and letting him go loose before, he and his servants must carry every thing upon their backs.

The farther we advanced in Vettie's Giel, our road became the more difficult and the more frightful. At one time you were stopped by snow that had tumbled down, and where it was only by passing quickly over the loose heaps you could avoid sliding down the steep, at once to be dashed against the rocks and to be drowned:—next you stood horrified at the sight of a wall of ice, the remainder of a frozen current, by which all farther advance seemed to be rendered impossible. But for this Civind had prepared himself. With his axe he cut in the clear solid ice a notch, in which he set one foot, then another in which he set his other foot, and in this manner continued to cut and go forward till he had reached the other side. The rest of us followed in the steps which he had thus cut. You must put on resolution; there is nothing else for it. With the utmost caution, your eye fixed steadily on the point where you are to tread, you set forward foot by foot, without stopping to draw your suppressed breath. For more than half a mile (more than three English miles,) we went forward on the brink of a perfect abyss, in this manner, sometimes passing masses of snow not yet melted, sometimes those huge frozen mirrors which hung almost perpendicularly from the summit of the mountain to the gulph below, and over which the axe only, by steps scarcely a handbreadth, could form for us a dangerous path. A slip, an unsteady step, or giddiness itself, which always threatens to overwhelm the unaccustomed traveller, and in a moment the torrent becomes the grave of your mangled carcase. But such is your whole course through Vettie's Giel, on a path where it is not often you can set down both feet beside each other.

When overcome by the violence of the exertions I had to make, I stopped a moment. This rest, so far from being refreshing to me, was full of horror. It was better to go on, however exhausted. In doing so, your thoughts were so occupied with the place where you might find some footing, that you had but little time to observe the grimaces with which death seemed every where to gape around you. But sit yourself down, you cannot avoid seeing yourself sitting on the brink of an abyss; above you the high mountain ridge hanging over your head, below the more frightful steep sinking perpendicularly from your feet: on the opposite side of the Giel, the widest torrents tumbling down hundreds of

fathoms; whilst at the bottom, the river foaming and roaring, with a deafening sound, rushed on with the rapidity of an arrow, and the road you had to go, bent still far upon the sides of the precipice which hung over it: in short, you saw nothing but Nature in her terrors: I involuntarily shut my eyes; my heart beat, and, that I might not be overpowered by these sensations, I stood up to expose myself to new dangers. I asked my guides if any body had ever come to mischief on this way. They recollected only one person, who, with a knapsack of birch-bark on his back, by a false step, had tumbled over from about the very spot where we were standing. From an irresistible apprehension that I might be the second, I pushed forward immediately from such a place, but yet I found no safer way.

It began now to rain, and as the part of the path on which we were, was considered as dangerous, from stones that tumble down, we made all the speed we could. The bottom of the Giel began at last to widen a little; and at Höliefoss, about half a quarter of a mile from Vettie, (three quarters English,) it becomes about 150 paces broad. In other places it is never above 30 ells broad, and in some places not more than 6 or 7. Here my guide Civind left me, and went back alone with his axe, of which he had made such good use, telling me that now all the difficulties of the way were past; and they were so in comparison of those we had come through.

Höliefoss is a fall in Utledal River itself, of no great height, but of force which you scarcely find in any other fall, and accompanied with a noise which deafens the ear. A mountain rock has here set itself fast in the bottom of the Giel: the river has been forced to dig itself a narrow passage between this rock and the high mountain precipice, between which it rushes forward with such irresistible violence, that stones thrown into it, or tumbling from the side of the mountain, are carried down on its surface.

It rained now so hard, that the water ran across our path: I quickened my pace, to reach the end of this fatiguing and dangerous excursion. With all my haste, however, I could not escape being thoroughly wet. The path now descended gradually towards the river. The mountain to the side of which, as to a wall, we had been, as it were, fastened the whole way, now turned a little off from us, leaving a broader, though an irregular way. On a sudden it goes off entirely to the right, opening a new side-valley, and before I knew where I was, I stood on the fields of Vettie, only a little above the surface of the river. Heavy with my wet clothes,

dropping with sweat, and exhausted by violent exertions, I was glad to reach the houseman's dwelling, which lay nearest us, there to repose a little, under cover, before I should attempt to mount the long and high hill on which stood the farm-house of Vettie.

On the road to it I was met by Olé, the goodman, who conducted me up. The family had just risen from dinner. Every thing was instantly carried off, as they did not think it good enough for me. On the table was immediately set their best butter and cheese, and smoked flesh, and flour-bread; and in short every thing they had to please the appetite of the weary traveller. But as there was not a dry thread on me, I felt very uncomfortable in my wet clothes. The goodman found a remedy for that; and from his chest I was provided with every thing I required. Clad from top to toe in his Sunday's clothes, I sat down, metamorphosed into a Leirdaller, amidst this friendly family, who could not cease from expressing their wonder at a visit as unexpected as unheard of before, and who did not know what kindness to shew me; complaining from their hearts, that I had not given them notice, that they might have been better prepared to receive me. His wife was in an advanced stage of pregnancy. I expressed my wishes for her safety on her approaching confinement; and asked her, how she would get the child taken to church.—O, answered she, smiling, when matters come that length, there will be no difficulty: the child is well wrapped up, and is carried to church, properly girt on the shoulders of the servant-man.—By the same way I have come?—Yes; we have no other.—Now, then, God be with both him and the child.—O, we are not afraid of the way, we are so accustomed to it; and after a few weeks it will be better, when all the ice will be away. By God's help I shall soon come to church myself, when Father* shall lead me in.—I could not but think highly of her courage, her cheerfulness and composure. The goodman told me, that at the best season in summer the Giel can be traversed by a horse; and that then every thing is thus brought to the house, on the back of his own horse, who is accustomed to this road. One is less surprised at this when he sees the

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* Meaning the clergyman to whom she was speaking. It is still the custom, in the remote and simple districts of Norway, that when a woman goes first to church after her confinement, the parish clergyman meets her at the door, and leads her into church.

lightness of the small Leirdal horses, and their most uncommon sure-footedness, by which they can go on the smallest paths, on the side of the most fearful precipices, setting one foot before another, in such a manner that no path can be too small for them. From the farm of Vettie, the Giel is continued upward, in a stretch of three miles, so that the whole length of it is more than four miles and a half (more than thirty English miles.) Above Vettie farm, the goodman told me, it was more narrow, more difficult, and more frightful, than the part of it which I had seen. He and his people had often to go up that way for small timber, and other things necessary on the farm. On the sides of it, too, were the finest valley and mountain pastures, of the greatest value to their rearing of cattle. Their corn was sometimes destroyed in harvest by frost. For more than half the year, the two families living on this farm, the farmer himself, and his houseman, are cut off from all other human intercourse. In winter, the ordinary path is impassable, from snow and ice, and especially from those frequent columns which leave traces of themselves a long way on in the summer, because the sun's rays, resting but a short time over this long, monstrous gulf, it is seldom before the month of July that this ice is all away. For a short time in winter, when the river Utledal is frozen, there may be a passage along the bottom of the Giel, but not without danger from the avalanches, which, with tremendous violence, tumble down into the deep; the very air of which overthrows every thing. In the end of harvest and the spring, all approach to and from Vettie is barred; in the end of harvest particularly, from the falling of earth and stones, which are then loosened by the frequent rains.

At a little distance behind the dwelling-house of Vettie, in the back ground of the dale, there rises up a large mountain precipice, over which, where a new Giel begins, there rushes the highest waterfall I had yet seen, called Markéfoss. High falls indeed are here so common, that they at least excite less attention, especially where the mass of water is not very considerable; but what seemed to me exceedingly singular in this one, was, that the fall is so perfectly perpendicular, that not one drop of its water touches the whole side of the mountain. From the gap through which it issues, the mountain bends inward like the side of an arch, in such a manner, that if the place were accessible, one might make a passage between the mountain and the fall. As the mass of water here meets with no resistance, it makes no alarm-

ing noise; I only heard its distant sound in the bottom of the Giel, which it was impossible for me to see, as all view and all approach is barred by high sharp-pointed rocks, and a chaotic assemblage of large blocks of granite. Over this precipice lie the pasture-grounds of Vettie, where are some of the finest sketches of wood to be found perhaps in the whole province. Here grow the finest trees for masts, of uncommon height and thickness, unused and incapable of being used, because they cannot be got down through the Foss, without being splintered into a thousand pieces. It is difficult to get even common house timber this way, for perhaps not one out of ten pieces remain of sufficient length. In former times, this wood was the property of the Copper-work Company of Aardal, which had its best supply of charcoal from it. It was the more valuable to them, that its situation excluded it from every other use. I saw a man going up the precipice which leads to this wood. At the distance at which I stood, he seemed like an insect creeping up a wall. By frequent turnings from one hand to another it is rendered possible to go up a path, from which, however, nothing is more easy than to break a neck. But born and brought up as the people are here amidst such dangers, they disregard or are not sensible of them. The boy, the youth, grows up amidst venturous feats; and courage is his life's constant guide. Of the mountain-summits here, I mention only Fleskeuaastiud, because it is considered as the highest next to the summits of the Young Harlots.

I spent the night at Vettie, and was next morning out with the goodman to have a full view of his little romantic dale, where hill and valley, wood and water, the lofty black mountain-masses, over which the majestic fall poured its foaming silver, were all grouped in the most picturesque manner, in a landscape in which the strongest features of Nature were wonderfully blended with her sweetest smiles. The severe and the gay moderated one another by being mingled in one look. The chorus of the feathered tribe only was wanting in wood and forest. The temperature here is too severe for the delicate songsters of the sky; nowhere does the lark mount in his airy flight; even the thrush flies to milder regions. The cuckoo only, with his monotonous song, for a short time enlivens the silence of the wood.

I had learned from the goodwife how they carry their children from this place to church. I was curious to learn of her husband, how they got the dead carried from it to the church-yard. It is impossible that two people could go

beside one another in the Giel; and I could not conceive that a coffin could be placed on horse-back. He gave me the following account. The dead body, wrapped in linen, is laid on a plank, in which are bored holes at both ends, to which are fastened handles of cord. To this plank the body is lashed, and is thus carried by two men, one before and another behind, through the Giel, till they come to the farm-house of Selde, where it is laid in a coffin, and carried in the common way to the church-yard. If any one die in winter, at a time when the bottom of the Giel is not passable, or in the spring or harvest, they endeavour to preserve the body in a frozen state, which is seldom difficult, till it can be carried off in the manner I have just mentioned. Still more singular was the method which the goodman told me was employed several years ago, to convey a dead body to the grave, from a houseman's place in Vormelien. This place lies in Utledale, which borders with the fields of Vettie. It has a most frightful situation, deep in the Giel, by the side of the river; and like Vettie, has no other road but a small steep path, on the side of the most dreadful precipices. As the inhabitants of this place had been often changed, there had been no deaths here. It happened, at last, for the first time, that a young man of seventeen years of age died. It never occurred to them to think how they should get him carried to the grave, and a coffin is prepared for him in the house. The body is laid in it and carried out; and now, for the first time, they perceive with amazement that it is impossible in this way to get on with it. What is to be done? Good counsel is here precious. They leave the coffin as a *memento mori* at home, and set the dead body astride on a horse; the legs are tied under the horse's belly, —a bag of hay is well fastened on the horse's shoulders, to which the body leans forward, and is made fast; and in this manner rode the dead man over the mountains to his resting place in Forthuus Church in Lyster,—a fearful horseman.

After a long and fatiguing weary walk, I returned with the goodman to his house. A rich soup, made from excellent wedder mutton, killed the night before, smoked from the white clad table. And what is not excellent when it is presented to you by hospitable hands! So long as nature and generous simplicity is preferred to art and ceremony, so long will such a patriarchal meal, to which you are invited with a welcome from the heart, and which is gratefully received, be preferred to ostentation and extravagance. They wished

me much to remain another day at Vettie; but as I had fixed to go that day to Afstdal, and then over the mountains to some of the mines at Aardal Copper-works, I was obliged to bid farewell to the worthy people, whose extraordinary place of residence I had for the first, and I believe also for the last time, now seen.

With my former guides, and a man-servant from Vettie, I set out on this fearful way back. From the heavy rain, much of the ice had disappeared; and I had the dangerous pleasure of seeing one of these masses of ice tumbling down in a thousand pieces into the gulf: over two only of the most obstinate were we obliged to cut our road over the ice. In good time I reached Ielde; and here, where nobody dreamt of danger, my horse tumbled with me over the side of a little hill. Thus ended an excursion, the whole object, and the whole result, of which was the view of Vettie's Giel.

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## Art. LX.—*Papers on Fluid Chlorine and on the Condensation of Several Gases into Liquids.* By Mr Faraday, Chemical Assistant in the Royal Institution. [*Phil. Trans.*]

### I. *On Fluid Chlorine.*

It is well known that before the year 1810, the solid substance obtained by exposing chlorine, as usually procured, to a low temperature was considered as the gas itself, reduced into that form: and that Sir Humphry Davy first showed it to be a hydrate, the pure dry gas not being condensible even at a temperature of — 40° F.

I took advantage of the late cold weather to procure crystals of this substance for the purpose of analysis. The results are contained in a short paper in the Quarterly Journal of Science, vol. xv. Its composition is very nearly 27.7 chlorine, 72.3 water, or 1 proportional of chlorine and 10 of water.

The President of the Royal Society having honoured me by looking at these conclusions, suggested that an exposure of the substance to heat under pressure, would probably lead to interesting results: the following experiments were commenced at his request. Some hydrate of chlorine was pre-

pared, and, being dried, as well as could be by pressure in bibulous paper, was introduced into a sealed glass tube, the upper end of which was then hermetically closed. Being placed in water at 60°, it underwent no change; but when put into water at 100°, the substance fused, the tube became filled with a bright yellow atmosphere, and, on examination, was found to contain two fluid substances: the one about three fourths of the whole, was of a faint yellow colour, having very much the appearance of water; the remaining fourth was a heavy bright yellow fluid, lying at the bottom of the former without any apparent tendency to mix with it. As the tube cooled, the yellow atmosphere condensed into more of the yellow fluid, which floated in a film on the pale fluid, looking very like chloride of nitrogen; and at 70° the pale portion congealed, although even at 32° the yellow portion did not solidify. Heated up to 100° the yellow fluid appeared to boil, and again produced the bright coloured atmosphere.

By putting the hydrate into a bent tube, afterwards hermetically sealed, I found it easy, after decomposing it by a heat of 100°, to distil the yellow fluid to one end of the tube, and to separate it from the remaining portion. In this way a more complete decomposition of the hydrate was effected, and, when the whole was allowed to cool, neither of the fluids solidified at temperatures above 34°, and the yellow portion not even at 0°. When the two were mixed together, they gradually combined at temperatures below 60°, and formed the same solid substances as that first introduced. If, when the fluids were separated, the tube was cut in the middle, the parts flew asunder as if with an explosion, the whole of the yellow portion disappeared, and there was a powerful atmosphere of chlorine produced; the pale portion on the contrary remained, and when examined, proved to be a weak solution of chlorine in water, with a little muriatic acid, probably from the impurity of the hydrate used. When that end of the tube in which the yellow fluid lay, was broken under a jar of water, there was an immediate production of chlorine gas.

I at first thought that muriatic acid and euchlorine had been formed; then, that two new hydrates of chlorine had been produced; but at last I suspected that the chlorine had been entirely separated from the water by the heat, and condensed into a dry fluid by the mere pressure of its own abundant vapour. If that were true, it followed, that chlorine gas, when compressed, should be condensed into the

same fluid, and as the atmosphere in the tube in which the fluid lay was not very yellow at 50° or 60°, it seemed probable that the pressure required was not beyond what could readily be obtained by a condensing syringe. A long tube was therefore furnished with a cap and stop-cock, then exhausted of air and filled with chlorine, and being held vertically with the syringe upwards, air was forced in, which thrust the chlorine to the bottom of the tube, and gave a pressure of about 4 atmospheres. Being now cooled, there was an immediate deposit in films, which appeared to be hydrate formed by water contained in the gas and vessels, but some of the yellow fluid was also produced. As this however might also contain a portion of the water present, a perfectly dry tube and apparatus were taken, and the chlorine left for some time over a bath of sulphuric acid before it was introduced. Upon throwing in air and giving pressure, there was now no solid film formed, but the clear yellow fluid was deposited, and more abundantly still upon cooling. After remaining some time it disappeared, having gradually mixed with the atmosphere above it; but every repetition of the experiment produced the same results.

Presuming that I had now a right to consider the yellow fluid as pure chlorine in the liquid state, I proceeded to examine its properties, as well as I could when obtained by heat from the hydrate. However obtained, it always appears very limpid and fluid, and excessively volatile at common pressure. A portion was cooled in its tube to 0°; it remained fluid. The tube was then opened, when a part immediately flew off, leaving the rest so cooled, by the evaporation, as to remain a fluid under the atmospheric pressure. The temperature could not have been higher than — 40° in this case; as Sir Humphry Davy has shown that dry chlorine does not condense at that temperature under common pressure. Another tube was opened at a temperature of 50°; a part of the chlorine volatilized, and cooled the tube so much as to condense the atmospheric vapour on it as ice.

A tube having the water at one end and the chlorine at the other, was weighed, and then cut in two; the chlorine immediately flew off, and the loss being ascertained was found to be 1.6 grain: the water left was examined and found to contain some chlorine; its weight was ascertained to be 5.4 grains. These proportions, however, must not be considered as indicative of the true composition of hydrate of chlorine; for, from the mildness of the weather during

the time when these experiments were made, it was impossible to collect the chrystals of hydrate, press and transfer them, without losing much chlorine; and it is also impossible to separate the chlorine and water in the tube perfectly, or keep them separate, as the atmosphere within will combine with the water, and gradually re-form the hydrate.

Before cutting the tube, another tube had been prepared exactly like it in form and size, and a portion of water introduced into it, as near as the eye could judge, of the same bulk as the fluid chlorine; this water was found to weigh 1.2 grain; a result, which, if it may be trusted, would give the specific gravity of fluid chlorine as 1.33; and, from its appearance in and on water, this cannot be far wrong.

## *Note on the Condensation of Muriatic Acid Gas into the Liquid Form.* By Sir H. Davy, Bart. Pres. R. S.

In desiring Mr Faraday to expose the hydrate of chlorine to heat in a closed glass tube, it occurred to me, that one of three things would happen: that it would become fluid as a hydrate; or that a decomposition of water would occur, and euchlorine and muriatic acid be formed; or that the chlorine would separate in a condensed state. This last result having been obtained, it evidently led to other researches of the same kind. I shall hope on a future occasion, to detail some general views on the subject of these researches. I shall now merely mention, that by sealing muriate of ammonia and sulphuric acid in a strong glass tube, and causing them to act upon each other, I have procured liquid muriatic acid: and by substituting carbonate for muriate of ammonia, I have no doubt that carbonic acid may be obtained, though in the only trial I have made the tube burst. I have requested Mr Faraday to pursue these experiments, and to extend them to all the gases which are of considerable density, or to any extent soluble in water; and I hope soon to be able to lay an account of his results, with some applications of them that I propose to make, before the Society.

I cannot conclude this note without observing, that the generation of elastic substances in close vessels, either with or without heat, offers much more powerful means of approximating their molecules than those dependent upon the application of cold, whether natural or artificial: for, as gases diminish only about $\frac{1}{480}$ in volume for every — degree of Fahrenheit's scale, beginning at ordinary temperatures, a very slight condensation only can be produced by the most powerful freezing mixtures, not half as much as would re-

sult from the application of a strong flame to one part of a glass tube, the other part being of ordinary temperature: and when attempts are made to condense gases into fluids by sudden mechanical compression, the heat, instantly generated, presents a formidable obstacle to the success of the experiment; whereas, in compression resulting from their slow generation in close vessels, if the process be conducted with common precautions, there is no source of difficulty or danger; and it may be easily assisted by artificial cold in cases when gases approach near to that point of compression and temperature at which they become vapours.

## II. *On the Condensation of Several Gases into Liquids.*

I HAD the honour a few weeks since, of submitting to the Royal Society a paper on the reduction of chlorine to the liquid state. An important note was added to the paper by the President, on the general application of the means used in this case to the reduction of other gaseous bodies to the liquid state; and in illustration of the process, the production of liquid muriatic acid was described. Sir Humphry Davy did me the honour to request I would continue the experiments, which I have done under his general direction; and the following are some of the results already obtained:

*Sulphurous Acid.*—Mercury and concentrated sulphuric acid were sealed up in a bent tube, and, being brought to one end, heat was carefully applied, whilst the other end was preserved cool by wet bibulous paper. Sulphurous acid gas was produced where the heat acted, and was condensed by the sulphuric acid above; but when the latter had become saturated, the sulphurous acid passed to the cold end of the tube, and was condensed into a liquid. When the whole tube was cold, if the sulphurous acid was returned on to the mixture of sulphuric acid and sulphate of mercury, a portion was reabsorbed, but the rest remained on it without mixing.

Liquid sulphurous acid is very limpid and colourless, and highly fluid. Its refractive power, obtained by comparing it in water and other media, with water contained in a similar tube, appeared to be nearly equal to that of water. It does not solidify or become adhesive at a temperature of 0° F. When a tube containing it was opened, the contents did not rush out as with explosion, but a portion of the liquid evaporated rapidly, cooling another portion so much as to leave it in the fluid state at common barometric pressure. It was however rapidly dissipated, not producing

visible fumes, but producing the odour of pure sulphurous acid, and leaving the tube quite dry. A portion of the vapour of the fluid received over a mercurial bath, and examined, proved to be sulphurous acid gas. A piece of ice dropped into the fluid instantly made it boil, from the heat communicated by it.

To prove in an unexceptionable manner that the fluid was pure sulphurous acid, some sulphurous acid gas was carefully prepared over mercury, and a long tube perfectly dry, and closed at one end, being exhausted, was filled with it; more sulphurous acid was then thrown in by a condensing syringe, till there were three or four atmospheres; the tube remained perfectly clear and dry, but on cooling one end to 0°, the fluid sulphurous acid condensed, and in all its characters was like that prepared by the former process.

Sulphurous acid vapour exerts a pressure of about two atmospheres at 45° F. Its specific gravity was nearly 1.42.

*Sulphuretted Hydrogen.*—A tube being bent, and sealed at the shorter end, strong muriatic acid was poured in through a small funnel, so as nearly to fill the short leg without soiling the long one. A piece of platinum foil was then crumpled up and pushed in, and upon that were put fragments of sulphuret of iron, until the tube was nearly full. In this way action was prevented until the tube was sealed. If it once commences, it is almost impossible to close the tube in a manner sufficiently strong, because of the pressing out of the gas. When closed, the muriatic acid was made to run on to the sulphuret of iron, and then left for a day or two. At the end of that time, much protomuriate of iron had formed, and on placing the clean end of the tube in a mixture of ice and salt, warming the other end, if necessary, by a little water, sulphuretted hydrogen in the liquid state distilled over.

The liquid sulphuretted hydrogen was colourless, limpid, and excessively fluid. It did not mix with the rest of the fluid in the tube, which was no doubt saturated, but remained standing on it. When a tube containing it was opened, the liquid immediately rushed into vapour; and this being done under water, and the vapour collected and examined, it proved to be sulphuretted hydrogen gas. As the temperature of a tube containing some of it rose from 0° to 45°, part of the fluid rose in vapour, and its bulk diminished; but there was no other change: it did not seem more adhesive at 0° than at 45°. Its refractive power appeared to be rather greater than that of water; it decidedly surpassed that of

sulphurous acid. The pressure of its vapour was nearly equal to 17 atmospheres at the temperature of 50°.

The specific gravity of sulphuretted hydrogen appeared to be 0.9.

*Carbonic Acid.*—The materials used in the production of carbonic acid, were carbonate of ammonia and concentrated sulphuric acid; the manipulation was like that described for sulphuretted hydrogen. Much stronger tubes are however required for carbonic acid than for any of the former substances, and there is none which has produced so many or more powerful explosions. Tubes which have held fluid carbonic acid well for two or three weeks together, have, upon some increase in the warmth of the weather, spontaneously exploded with great violence; and the precautions of glass masks, goggles, &c. which are at all times necessary in pursuing these experiments, are particularly so with carbonic acid.

Carbonic acid is a limpid colourless body, extremely fluid, and floating upon the other contents of the tube. It distils readily and rapidly at the difference of temperature between 32° and 0°. Its refractive power is much less than that of water. No diminution of temperature to which I have been able to submit it, has altered its appearance. In endeavouring to open the tubes at one end, they have uniformly burst into fragments, with powerful explosions.

Its vapour exerted a pressure of thirty-six atmospheres, at a temperature of 32°.

*Euchlorine.*—Fluid euchlorine was obtained by enclosing chlorate of potash and sulphuric acid in a tube, and leaving them to act on each other for 24 hours. In that time there had been much action, the mixture was of a dark reddish brown, and the atmosphere of a bright yellow colour. The mixture was then heated up to 100°, and the unoccupied end of the tube cooled to 0°; by degrees the mixture lost its dark colour, and a very fluid ethereal looking substance condensed. It was not miscible with a small portion of the sulphuric acid which lay beneath it; but when returned on to the mass of salt and acid, it was gradually absorbed, rendering the mixture of a much deeper colour even than itself.

Euchlorine thus obtained is a very fluid transparent substance, of a deep yellow colour. A tube containing a portion of it in the clean end, was opened at the opposite extremity; there was a rush of euchlorine vapour, but the salt plugged up the aperture: whilst clearing this away, the

whole tube burst with a violent explosion, except the small end in a cloth in my hand, where the euchlorine previously lay, but the fluid had all disappeared.

*Nitrous Oxide.*—Some nitrate of ammonia, previously made as dry as could be by partial decomposition, by heat in the air, was sealed up in a bent tube, and then heated in one end, the other being preserved cool. By repeating the distillation once or twice in this way, it was found, on after-examination, that very little of the salt remained undecomposed. The process requires care. I have had many explosions occur with very strong tubes, and at considerable risk.

When the tube is cooled, it is found to contain two fluids, and a very compressed atmosphere. The heavier fluid, on examination, proved to be water, with a little acid and nitrous oxide in solution; the other was nitrous oxide. It appears in a very liquid, limpid, colourless state; and so volatile, that the warmth of the hand generally makes it disappear in vapour. The application of ice and salt condenses abundance of it into the liquid state again. It boils readily by the difference of temperature between 50° and 0°. It does not appear to have any tendency to solidify at —10°. Its refractive power is very much less than that of water, and less than any fluid that has yet been obtained in these experiments, or than any known fluid. A tube being opened in the air, the nitrous oxide immediately burst into vapour.

The pressure of its vapour is equal to above 50 atmospheres at 45°.

*Cyanogen.*—Some pure cyanuret of mercury was heated until perfectly dry. A portion was then enclosed in a green glass-tube, in the same manner as in the former instances, and being collected to one end, was decomposed by heat, whilst the other end was cooled. The cyanogen soon appeared as a liquid: it was limpid, colourless, and very fluid; not altering its state at the temperature of 0°. Its refractive power is rather less, perhaps, than that of water. A tube containing it being opened in the air, the expansion within did not appear to be very great; and the liquid passed with comparative slowness into the state of vapour, producing great cold. The vapour, being collected over mercury, proved to be pure cyanogen.

A tube was sealed up with cyanuret of mercury at one end, and a drop of water at the other; the fluid cyanogen was then produced in contact with the water. It did not mix, at least in any considerable quantity, with that fluid,

but floated on it, being lighter, though apparently not so much so as ether would be. In the course of some days, action had taken place, the water had become black, and changes, probably such as are known to take place in an aqueous solution of cyanogen, occurred. The pressure of the vapour of cyanogen appeared to be 3.6 or 3.7 atmospheres at 45° F. Its specific gravity was nearly 0.9.

*Ammonia.*—When dry chloride of silver is put into ammoniacal gas, as dry as it can be made, it absorbs a large quantity of it; 100 grains condensing above 130 cubical inches of the gas: but the compound thus formed is decomposed by a temperature of 100° F., or upwards. A portion of this compound was sealed up in a bent tube, and heated in one leg, whilst the other was cooled by ice or water. The compound thus heated under pressure, fused at a comparatively low temperature, and boiled up, giving off ammoniacal gas, which condensed at the opposite end into a liquid.

Liquid ammonia thus obtained was colourless, transparent, and very fluid. Its refractive power surpassed that of any other of the fluids described, and that also of water itself. When the chloride of silver is allowed to cool, the ammonia immediately returns to it, combining with it, and producing the original compound. During this action a curious combination of effects takes place: as the chloride absorbs the ammonia, heat is produced, the temperature rising up nearly to 100°; whilst a few inches off, at the opposite end of the tube, considerable cold is produced by the evaporation of the fluid. When the whole is retained at the temperature of 60°, the ammonia boils till it is dissipated and re-combined. The pressure of the vapour of ammonia is equal to about 6.5 atmospheres at 50°. Its specific gravity was 0.76.

*Muriatic Acid,*—When made from pure muriate of ammonia and sulphuric acid, liquid muriatic acid is obtained colourless, as Sir Humphry Davy had anticipated. Its refractive power is greater than that of nitrous oxide, but less than that of water; it is nearly equal to that of carbonic acid. The pressure of its vapour at the temperature of 50°, is equal to about 40 atmospheres.

*Chlorine.*—The refractive power of fluid chlorine is rather less than that of water.—The pressure of its vapour at 60° is nearly equal to 4 atmospheres.

Attempts have been made to obtain hydrogen, oxygen, fluoboracic, fluo-silicic, and phosphuretted hydrogen gases,

in a liquid state; but though all of them have been subjected to great pressure, they have as yet resisted condensation. The experiments will, however, be continued on these and other gases, in the hopes that some of them at least, will ultimately condense.

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## Art. LXI.—*Observations on Bees, and particularly on the conversion of the Larvæ of Working-Bees into Queen-Bees.* By the Reverend Mr Dunbar of Applegarth. [*Ed. Phil. Jour.*]

Among my experiments in the year 1822, there were two rather of an interesting nature, one of them confirming beyond the possibility of a doubt, the remarkable and often-questioned fact in the natural history of bees, of their having the power of converting the larva of a working-bee into a queen, when circumstances require such an expedient; the other experiment is completely practical in its nature, and the consequence of the one first mentioned.

*Experiment* I.—In a communication inserted in the Philosophical Journal, I mentioned an instance which I had witnessed of the formation of a queen from the egg of a working bee;—a discovery for which Natural History is indebted to Schirach, and which had been repeatedly verified by the celebrated Huber. Possessing a hive extremely well fitted for experiments of this kind, and which I have named the *Mirror-Hive*, from its exact resemblance to that piece of household furniture, I set about repeating this experiment in such a way as to put the matter out of all doubt. Huber had already done this so accurately that no person at all conversant in this branch of natural history could reasonably have felt any hesitation on the subject, provided there was no favourite theory to be upheld. But Huber was a foreigner, and I have heard it alleged against him by some, that he was a man of a very vivid immagination,—and by others, that being defective in his eye-sight, he had given credit on the word of his assistant to reports of discoveries unfounded in fact. Huish, an Englishman, has published a

Treatise on Bees, in which he treats with much petulance and ridicule the theory of the formation of artificial queens, so warmly supported by Huber; and I observe in the London list of new publications, a pamphlet announced by him in answer to my paper on that subject in this Journal. The following results of an experiment I made last summer, will, I presume, be regarded as a conclusive answer to his objections, and to those of any others who may be sceptical on the point.

In July the Mirror-Hive was full of comb, bees, brood, and honey,—the queen very fertile, and laying at the rate of 100 eggs *per diem.* I opened the hive and took her away. For eighteen hours they continued to labour as if she were still with them; at the end of that time they missed her, and all was instantly agitation and tumult; the bees hurried backwards and forwards over the comb with a loud noise, rushed in crowds to the door, and out of the hive as if they were swarming, and, in short, exhibited all the symptoms of bereavement and despair. Next morning they had laid the foundation of five queen cells, having demolished the three contiguous cells to the one containing a worm which suited their purpose, and by the afternoon four more, all in parts of the comb where before were nothing but eggs and common worms of one or two days old. Two of these royal cells advanced more rapidly in size than the rest, probably from the larvæ being of an age fittest for the purpose; four came on more slowly, and three made no progress after the third day. On the seventh day the two first were sealed, two more were nearly so, all the rest continued stationary, and in fact remained so, as if the bees, satisfied that they had at least secured one queen, did not think it necessary to carry forward the others to maturity. On the morning of the fourteenth day from the removal of their old queen, a young one emerged from her cell, strong, active, and exactly resembling those produced in the natural way. While examining her motions, I saw her hasten to the other royal cell, which had been closed about the same time with the one from which she had come, and attempt to tear it open, doubtless with a view of destroying its inmate; but the working-bees pulled her away with violence, and continued to do so as often as she made the attempt. At every repulse, she stood, in a sulky posture apparently, on the comb, and emitted the shrill *peep peep*, so well known to bee-masters, while the unhatched queen at the same time sent forth a

peep also, but of a hoarser kind. And this accounts for the two different sounds which are generally heard in the evening from a hive about to throw a second swarm. The shrill sound proceeds from the reigning queen, and seems to express her rage and disappointment at being baffled by the watchful guardians of the unhatched queen, from whom the hoarse sound comes. In the afternoon of the same day the last mentioned female left her cell. I saw her come forth in majesty, finely and delicately formed, but smaller than the other. She immediately retired within a cluster of bees, and I lost sight of her. Next morning, on opening the shutter of the hive, I perceived the youngest queen rushing apparently in great terror over the face of the comb, and turning round the edge of it to the other side; and in the next moment the other queen was seen pursuing with equal rapidity. I now fully expected to witness Huber's combat of queens, and was about to wheel round the hive on its pivot, to inspect their proceedings on the other side, when business called me off. I returned in half an hour, thinking I might yet be in at the death, but found all was over! The young queen was lying on the alighting-board on her back, in the pangs of death, newly brought out by the bees, and doubtless the victim of the elder queen.

I observe two circumstances respecting this last queen, one of which agrees perfectly with the experience of Huber, while the other is at variance with it. While the young queen remained a virgin, not the slightest respect was paid her by the bees; not one gave her food, she was obliged to help herself, and in crossing towards the honey-cells, she had to scramble over the crowd, not an individual of which would get out of her way, or seemed to care whether she fed or starved. But no sooner did she begin laying than the scene was changed, and complaisance, respect and attention, became the order of the day; one after another extended the proboscis with food, and at every step of her progress a circle was formed round her by her admiring people. The other circumstance, and which varies from the experience of Huber, respects the sound emitted by the queens. He says that the workers form no guard around the cells of artificial queens,—that these are perfectly mute, and he makes several remarks by way of accounting for it. The above experiment completely contradicts this. The cell of the young queen was guarded most vigilantly, and both emitted the sounds alluded to, perhaps once every minute, for several hours together.

*Experiment* II.—This experiment, which was entirely practical, and consisted in turning to account the result of the first experiment, respected the formation of artificial swarms, an expedient, in my opinion, never to be resorted to, but in such cases of necessity as that I am about to detail. From the first to the third week of June my hives had all thrown their top-swarms; but instead of throwing their second in ten or twelve days thereafter, as is generally the case, four of them had not cast nearly three weeks after. This was probably owing to the unfavorable state of the weather, which, by delaying the swarming, had furnished the reigning queen with an opportunity of putting to death one or two of her intended successors. In these circumstances, from the crowded state of the hive, a mass of bees as large as a man's head hung from the alighting-board of each hive; a sight grievous to the Apiarian, as these outliers are quite idle. Determined to avail myself of Schirach's and Huber's discoveries, I cut out of the Mirror-hive a piece of comb about three inches square, containing eggs and worms, and fixed it in an old hive full of empty comb. I then removed out of sight one of the hives which had an outlying, or rather outhanging, mass on its alighting-board, instantly clapped down in its place on said board the empty hive, and forced the idlers to enter. They made a tremendous noise, and seemed disconcerted at finding, instead of the rich combs they had hitherto been familiar with, nothing but empty cells. This agitation was kept up all day by the continued arrival of the bees belonging to the original hive, who had been abroad when their habitation was changed, and who now added greatly to the population. At noon next day I inspected the new establishment (a leaf-hive of Huber,) and found, to my satisfaction, the foundations of three queen-cells laid in the small piece of brood-comb I had given them. In due time a queen was hatched,—the hive prospered, and at the end of the season I took from it four and a half pints of honey. Finding this trial succeed so well, I instantly fell to work with two more in similar circumstances, and with the same success. One of these died about a month after, but from causes which had no connexion with the experiment; the other I kept over winter, and it has now swarmed, (July 1, 1823.)

I had still another which hung out, and from this also I forced a cast, but by a method which has been often adopted by others. I carried a full hive into a dark place, turned it up, placed an empty hive over it, mouth to mouth, and *drove* it partially. Perceiving that half the bees had gone

up, and knowing that in these cases the queen is always among the foremost, I immediately replaced the old hive in its former station, and carried the new one, containing the queen, to a little distance. As the old hive had plenty of eggs and young brood, the bees were at no loss to procure another queen; and the new one having a queen, proceeded to work in all respects as a natural young swarm. The old one I kept over winter, and it cast this summer.

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## Art. LXII.—*Account of a Journey across the Island of Newfoundland.* By W. E. Cormack, Esq. [*Ed. Phil. Jour.*]

In the beginning of September 1822, I left Smith's Sound, at Random Island, accompanied only by one Micmac Indian: and accompanied by two of that tribe, reached St George's Harbour in the beginning of November. I encountered more impediments in accomplishing the undertaking than were contemplated at setting out. These chiefly arose from having to walk round numerous lakes, which, in the eastern division of the island, are generally surrounded with wood; and from the ground being covered with snow, to a considerable depth, after the 15th of October.

My courses were determined merely by a pocket compass; from which circumstance, and from being the first traveller over this country, I only had it in my power to ascertain its general nature and outline. There is much of the interior under water; it may be said, within bounds, at least one-third of the whole of it.

The first rocks we met with were granite and porphyry. These were succeeded by alternations of granite and mica-slate, which, in their turn, were replaced by granite. Granite, sienite, porphyry, mica-slate, clay-slate, and quartz-rock, occur in the district occupied by Melville Lake. In the same district there are several kinds of secondary sandstone, belonging, probably, to the coal and red sandstone formations. The primitive rocks extend onwards to Gower's Lake. The shores of this lake bear a strong resemblance to the shores of Fresh-water Bay near St Johns. This lake has also a dry stony bar, or bank, about its middle,

running nearly across from its north-west side; the other has a bar extending across, and separating the fresh water from the salt. From Gower's Lake, by Jenette's Lake, Emma's Lake, Christian's Lake, Stewart's Lake, Richardson's Lake, the country is almost entirely of old rocks, apparently of the primitive class; the only indications of secondary rocks being the agates near Gower's Lake, the basalt at Emma's Lake and Jenette's Lake, and the indication of coal and iron near Stewart's Lake. The serpentine deposite is succeeded by a great tract of granite, gneiss, and quartz, which extends from Jameson's Lake, by Bathurst's Lake, Wallace's Lake, Wilson's Lake, King George the Fourth's Lake, to St. George's Harbour, in the Bay of St. George, on the west coast of the island*.

About the centre of the island are several ridges of serpentine. Here this rock is seen in all its beautiful and numerous varieties; and this occurs particularly on the shores of Serpentine Lake. The Serpentine Mountain and Jameson's Mountain also abound in this interesting mineral.

The west coast is by far the richest in minerals. There is coal of a good quality in St. George's Bay, about eight miles from the sea-coast, up the South Barrasway River. There are several salt springs; one about two miles from the sea-coast, up another Barrasway River, some miles north of that where the coal is found; another, a few miles still farther north, up what is called Rattling Brook; and a third at Port-a-Port. There is a strong sulphurous spring, close to the sea-shore, about a mile north of the Barrasway River, where the salt-spring first mentioned is found, (apparently what is called the Second River by the chart.) Gypsum and red ochre abound between these rivers and Flat Bay, at the sea-shore; and the former is also found some miles within the country. There is a dark grey coloured marble found at Bay of Islands; but, from report, in no great quantity near the coast. The soil of St George's Bay is good, and not so rocky as in most parts of the island.

There does not appear to be any good soil in the interior. It is almost invariable peat marsh, more or less wet, according to situation, the more elevated parts being rocky. The

* I have used the customary privilege of giving names to the lakes and mountains I met with in this hitherto unexplored route, and these are in compliment to distinguished individuals and private friends. The rocks I collected were examined by Professor Jameson.

stunted woods almost invariably indicate its poverty. The short summer does not allow the sun sufficient time to draw out, even from the more elevated *sloping* districts *in their natural state*, the wet of the preceding winter. The best soil in the island is near the sea-coasts, particularly the banks next to the mouths of some of the large rivers.

The eastern half of the interior is a low picturesque woody country, traversed northerly and southerly by successive ridges of low hills. The western half is mountainous, often rugged, barren and nearly destitute of wood; but the mountains here do not lie in ridges, nor in any particular direction, and the lakes and rivers are much larger than to the eastward.

The most extensive lake in Newfoundland is called the Bay of Islands Lake, said by the Indians to be 60 miles long. The second is called the Lake of the Red Indians.

The largest river is Exploit River. The river of East Bay, in the Bay of Despair, admits of the Micmac Indians taking up their birch-bark canoes from the sea-coast to Serpentine Lake. After that, they go on their hunting excursions, from lake to lake, in skin canoes, by means of the rivers, and, occasionally, by portages. From St George's Bay there is a portage of upwards of twenty miles to George the Fourth's Lake, before the Indians enter upon the great lakes of the interior.

Roads, or rather paths, which would admit of horses and cattle passing in summer, could be made across any part of the interior. The chief labour and expence attending their formation, would consist, in surveying the routes, to avoid lakes, and in general, woods; the latter frequently covering very rocky districts. With proper and seasonable care, considerable quantities of wild hay could be procured from the marshes. Were Government to countenance the facilitating a communication overland, between St John's and the neighbouring bays, the intercourse would become more frequent and less dangerous than it has been, particularly in winter.

In a botanical point of view, the interior does not appear to be particularly interesting, after having examined the country near the sea-coast. The island altogether, however, affords a wide field for research to the botanist, particularly as to shrubs. The naked parts of the country, in general, including the marshes, exhibit appearances of having been once wooded. Roots and trunks of trees are generally found under the surface. Many are of larger dimensions

than any now growing in their vicinity. They have evidently been destroyed by fire; and from the poor soil in this cold region several centuries seem necessary to produce a forest of any magnitude. A thin wiry grass, with lichens and mosses, cover the marshes; and these, with whortleberry bushes, and several diminutive shrubs, predominate on the higher unwooded districts. Spruces, Larch, and Birches, compose the woods. The pine is seldom seen, and is commonly so stunted or shrubby, as to be of little value for timber. The mountain-ash is sometimes met with. The only good timber in Newfoundland grows near the sea coasts, and particularly, on the banks of the large rivers, where the best soil is found.

The western division being nearly destitute of wood, affords pasture to numerous herds of deer (the *Carribou.*) Of these animals there are here many thousands; indeed, the country seems covered with them. They migrate eastward to the woody districts in winter, and return westward very early in spring. Their flesh forms almost the sole subsistence of the Indians.

Beavers have, in former times, abounded in all the woody districts, and in some places considerable numbers of them are still found, particularly north of the Bay of Despair and Fortune Bay, and in the vicinity of White Bay.

The other wild animals of the country are not numerous, except foxes, near the sea-coast.

Geese, ducks, and gulls, with some other aquatic birds of passage, breed in considerable numbers in the interior. They collect in flocks, and leave it for the coast, as soon as the ponds are frozen over.

The Micmac Indians visit the interior chiefly in pursuit of beavers. They generally allow the different districts where these animals are found, a periodical respite of three years, visiting them alternately in the autumn, in small hunting parties. On these occasions the Indians generally take their families with them. The canoes used on the lakes are partly from necessity, and partly for the sake of convenience, made of basket-work, covered over outside with deer-skins; the latter requiring to be renewed commonly once in six weeks. In construction these canoes resemble those of the antient Britons.

The whole number of this tribe in Newfoundland does not, in as far as I could learn, much exceed 100. They are generally divided into three bands; one at Flat Bay in St. George's Bay; one at Great Cod Bay river, and one at

Bay of Despair, near Weasel Island. Part of them occasionally resort to two or three favourite places on the coast.

The attention of government has several times been turned towards endeavouring to open an intercourse with the Red Indians. All attempts hitherto to accomplish this object have been unsuccessful. The failure may, on very good grounds, be attributed to the interference of the Micmacs. The latter are jealous lest, if any intercourse were established with the English, the others should share in the fur trade. To prevent this, they take most effectual methods of impressing these timid creatures with a dread of their fire-arms, and of leading them to entertain the same fears from the fire-arms of the English.

The value of this piece of policy appears to be well understood by the Micmacs, and has been pursued unknown to the English. By a judicious management, however, the Micmacs might be made instrumental in bringing about the intercourse so much desired. As a first step towards it, it might not be improper for our Colonial Government to threaten in a manner suited to the occasion, such of the Micmacs as injure any of the other tribe, with severe punishment, and offer rewards to such of them as will interfere and bring about a friendly intercourse between the Red Indians and the English.

The Red Indians are not numerous. Judging from the extent of country which they inhabit, their number cannot exceed a few hundreds. They do not appear to go now farther south into the interior, than the vicinity of the Great Lake, the shores of which they inhabit, and which bears their name. They communicate with the sea from this lake by Exploit River.

It is a common report that the Micmacs plunder this tribe of their furs. There is no doubt that they frequent the Red Indian territory, and studiously conceal from the English the nature and object of such visits.

The Micmacs say, among other things, of the Red Indians, that they catch deer in the *pound* and kill them with spears, and that they dry great quantities of their flesh in autumn, as provision for winter. They also complain, that when they are encamped in the country of the Red Indians, the latter, during the night, steal their axes. And they even affirm that this tribe are in the habit of devouring each other.

I discovered no traces of them, although I was, by the account of some Micmacs whom I met with hunting in the interior, at one time within twenty-five miles of their country.

I regretted very much that the smallness of my party, and more particularly the late season of the year, rendered it imprudent to go far enough north, to have an opportunity of seeing them.

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ART. LXIII.—*An Account of the Effect of Mercurial Vapours on the Crew of His Majesty's Ship Triumph, in the year* 1810. By WM. BURNET, M. D. one of the Medical Commissioners of the Navy, formerly Physician and Inspector of Hospitals to the Mediterranean Fleet. [*Phil. Trans.*]

IT has long been known, that in the vacuum of barometers, mercury rises in a vaporous state at the usual temperature of this climate, and that persons employed in the mines from whence this metal is produced, as well as those who are employed in gilding and plating, have suffered paralytic and other constitutional affections, from inhaling the air saturated with mercurial vapours: had any doubt remained of mercury existing in the state alluded to, it would be effectually removed by the experiments made by Mr Faraday, detailed in the twentieth number of the Journal of Science, &c.

An unprecedented event which occurred in one of His Majesty's ships of the line, at Cadiz, in the year 1810, a short time before I took upon me the charge of the medical department of the Mediterranean Fleet, has afforded me an opportunity of illustrating this subject on a very extensive scale, the details of which may not, perhaps, be uninteresting to the Royal Society.

The Triumph, of 74 guns, arrived in the harbour of Cadiz, in the month of February 1810; and in the following March a Spanish vessel, laden with quicksilver for the mines in South America, having been driven on shore in a gale of wind, and wrecked under the batteries then in possession of the French, the boats of this ship were sent to her assistance, by which means, during many successive nights, about one hundred and thirty tons of the quicksilver were saved and

carried on board the Triumph, where the boxes containing it were principally stowed in the bread-room.

The mercury, it appears, was first confined in bladders, the bladders in small barrels, and the barrels in boxes. The heat of the weather was at this time considerable, and the bladders, having been wetted in the removal from the wreck, soon rotted, and the mercury to the amount of several tons, was speedily diffused through the ship, mixing with the bread, and more or less with the other provisions. The effect of this accident was soon seen, by a great number of the ship's crew, as well as several of the officers, being severely affected with ptyalism, the surgeon and purser being among the first and most severely affected, by the mercury's flowing constantly into their cabins from the bread-room; their cabins being, as is usual, on the orlop deck, separated from this store by partitions of wood.

In the space of three weeks from the mercury's being received on board, two hundred men were afflicted with ptyalism, ulcerations of the mouth, partial paralysis in many instances, and bowel complaints. These men were removed into transports where those more slightly affected soon got well; but fresh cases occurring daily, Rear Admiral Pickmon, then in command of the squadron, ordered an inspection to be made by the surgeons thereof, and, in consequence of their report, sent the Triumph to Gibraltar to remove the provisions, and purify the ship by ablution, the affected men being sent to the Naval Hospital; which order was strictly adhered to; the provisions, stores, and likewise the shingle ballast, being removed on shore.

Notwithstanding the removal of the provisions, &c. and afterward frequent ablution, on re-stowing the hold, every man so employed, as well as those in the steward's room, were attacked with ptyalism; and during the ship's passage, and on her return to Cadiz, the fresh attacks were daily and numerous till the 13th of June, when the Triumph sailed for England.

After their departure from Cadiz they experienced fresh breezes from the N. E.; and the men being kept constantly on deck, the ship aired night and day by windsails, the lower deck ports allowed to remain open at all times when it could be done with safety, allowing no one to sleep on the orlop deck, and none affected with ptyalism on the lower deck, a very sensible decrease in the number daily attacked soon became apparent; but nevertheless, many of those already affected became worse, and they were under the

necessity of removing twenty seamen and the same number of marines, with two serjeants and two corporals, to a sloop of war and the transports in company. On their arrival at Cawsand Bay, near Plymouth, on the 5th of July, not one remained on the list for ptyalism.

The effects of the mercurial atmosphere were not confined to the officers and ship's company; almost all the stock, consisting of sheep, pigs, goats, and poultry, died from it; mice, cats, a dog, even a canary bird, shared the same fate, though the food of the latter was kept in a bottle closely corked up.

The surgeon (Mr Plowman) informed me, in conversation, that he had seen mice come into the ward-room, leap up to some height, and fall dead on the deck.

The Triumph, previous to this event, had suffered considerably, by having a number of her men attacked with malignant ulcers, which at one time prevailed to a considerable extent in our ships, both at home and abroad; and in many of the men who had so suffered, the ulcers, which had long been completely healed, without even an erasure of the skin, broke out again, and soon put on a gangrenous appearance.

The vapour was very deleterious to those having any tendency to pulmonic affections: three men died of phthisis pulmonalis, who had never complained, or been in the list before they were saturated with the mercury; and one man who had suffered from pneumonia, but was perfectly cured, and another who had not had any pulmonic complaint before, were left behind at Gibraltar, labouring under confirmed phthisis. Two only out of so large a number affected died from ptyalism, gangrene having taken place in their cheeks and tongue; they had previously lost all their teeth. In the case of a woman who was confined to bed in the cockpit with a fractured limb, not only were all the teeth lost but many exfoliations also took place from the upper and lower jaws.

The mercury showed its effects upon the ship herself, by the decks being covered with a black powder; but quicksilver was not discovered at any time in this powder in a native or globular state, though the brass cocks of the boilers, and the copper bolts of the ship were covered with the metal, the last to some extent within the wood; a gold watch, gold and silver money kept in a drawer, and likewise some of the iron-work of the ship which had been kept bright, evidently showed the influence of the prevailing atmosphere, being in some places covered with quicksilver.

In a communication with which Mr Plowman, surgeon of the Triumph, has obliged me, he states, that those who messed and slept on the orlop and lower decks, with the exception of the midshipmen, suffered equally, while those on the main or upper deck were not so severely affected: the men who lived and slept under the forecastle escaped with a slight affection of the gums. The only reasons which can be assigned for the partial escape of the midshipmen, are, that the windsails were kept always in action, and that these gentlemen were almost constantly on deck, or were more frequently employed on service out of the ship in proportion to their numbers, than the men.

Various opinions were entertained of the manner in which the systems of the sufferers were brought under the influence of the mercury. By some, it was supposed to have originated from the use of the bread and other provisions, with which the mercury had mixed itself: and to such an extent was this opinion carried, that I find, by reference to official documents in the Victualling Office, seven thousand nine hundred and forty pounds of biscuit were condemned as unserviceable from having *quicksilver mixed with it.*

By others, among whom was Mr Plowman, the surgeon, it was considered to have arisen from inhaling the mercurialized atmosphere; and from the preceding details, I think there cannot remain a doubt that this opinion was the true one.

It is well known, that mercury, in its native state has often been administered in very large doses in cases of obstinate constipation, without producing any specific effect on the system, merely removing the affection by its specific gravity. I have, however, reason to believe, from the accounts of Orfila and others, that if the mercury was to be retained in the intestines for some time, and thus subjected to the action of the contents of the stomach and bowels, a part might become oxidated, and being conveyed into the system by means of the absorbents, would there show its specific effects.

But after the removal of the provisions, &c. at Gibraltar, many fresh cases occurred, and many relapses among those who had been cured out of the ship, took place on their return to duty on board, which effectually destroys the probability of this having been the cause of the succeeding ptyalism, and other morbid affections.

It only remains for me to offer my opinion, of the manner in which the system became saturated by the mercury; and

this I conceive to have been effected by inhaling the mercurial vapours; the quicksilver being then in the most perfect state of division, was readily taken up by the absorbents of the lungs, and soon showed its influence on the system generally. This idea is very much strengthened by the effect which was produced on the animals on board, already mentioned, as well as by the circumstance of a great number of men being attacked after the ship was cleared at Gibraltar and till she arrived in a more northern latitude.

It may be considered out of place here, to give any detail of the curative means employed. I shall therefore only briefly state, that sulphur given in large quantities internally, produced no alleviation in the symptoms; on the contrary, it greatly augmented the bowel complaints, with which many of the men were afflicted, and brought on a most severe tenesmus; consequently it was laid aside: applied externally it was of no use.

The only plan which produced effectual relief was removal from the ship, with the frequent use of small doses of neutral salts and detergent gargles.

## Art. LXIV.—*Remarks on some of the American Animals of the Genus Felis, particularly on the Jaguar, Felis Onca Linn.* By T. S. Traill, M. D. F. R. S. E., &c. [*Mem. Wern. Soc.*]

Among the genera into which Linnæus has distributed the higher animals, none seems more natural, or better defined, than the genus *Felis;* yet such are the vague descriptions given by most travellers, and by the older naturalists, that we are still in uncertainty respecting several of the species which compose it. My attention has been particularly drawn to this genus, by accidentally meeting with skins, and occasionally with living animals belonging to it, which I have in vain endeavoured to reconcile to the descriptions of authors; and the magnificent collection of zoological drawings in the possession of Lord Stanley has made me acquainted with several of the feline genus, which do not ap-

pear to have attracted the attention of our best systematic writers.

The feline animals belonging to the American Continent are numerous, and have generally been ill described by naturalists. Indeed there appears to be a singular prejudice respecting them in the minds of many zoologists. Because neither the lion nor the tiger (the monarchs of the forest in the Old World) is found in America, it was a favourite dogma with a celebrated author, that the beasts of prey of the New Continent were inferior in courage and ferocity to those animals of the Old World, which they most nearly resembled. It is true, that none of the beasts of prey of America equal in size and power the lion of Africa, or the great tiger of Bengal: but the jaguar, the puma, and black tiger of South America, equal in courage and ferocity the panther, leopard, and onca, the animals of the other continents which they approach most nearly in size and habit.

Buffon and some other writers have described the jaguar and puma as destructive to other quadrupeds, but as cowardly and fleeing from the approach of man. It is now well ascertained that Buffon has confounded the true jaguar of South America with the ocelot, a much smaller and less formidable animal; and his account of the puma seems to be taken from the descriptions of those who have only seen the animal in the vicinity of human civilization. That eloquent writer has admitted the commanding influence of the experience of human prowess in subduing the courage of even his favourite animal the lion. "A single lion of the desert will frequently attack a whole caravan; and if, after a violent and obstinate encounter, he experiences fatigue, instead of flying, he retreats fighting with a bold front to his pursuers. Those lions, on the contrary, who dwell in the neighbourhood of the towns and villages of India and Barbary, being acquainted with man, and having felt the power of his weapons, have lost their native courage to such a degree, that they fly from the threatenings of his voice, and dare not assail him. They content themselves with preying on small cattle; and will fly before women and children, who make them indignantly quit their prey, by striking them with clubs."

Had Buffon not been trammelled by a favourite hypothesis respecting the alleged inferiority of the animal kingdom in America, he would have seen that the writers who notice the cowardice of the larger beasts of prey of that continent, only speak of them as observed near European colonies,

where their native ferocity has been compelled to acknowledge the superiority of human intellect and arms. Recent observations have shown how ill founded these speculations of the French naturalist have been.

Humboldt mentions many instances of the ferocious courage of the great jaguar. Among others, an animal of this species had seized a horse belonging to a farm in the province of Cumana, and dragged it to a considerable distance. "The groans of the dying horse," says Humboldt, "awoke the slaves of the farm, who went out armed with lances and cutlasses. The animal continued on its prey, awaited their approach with firmness, and fell only after a long and obstinate resistance. This fact, and a great many others, verified on the spot, prove that the great jaguar of Terra Firma, like the jaguaret of Paraguay, and the real tiger of Asia, does not flee from man, when it is dared to close combat, and when it is not alarmed by the great number of its assailants. Naturalists are now agreed, that Buffon was entirely mistaken with respect to the largest of the feline genus of America. What that celebrated writer says of the cowardly *tigers* of the New Continent relates to the small ocelots; and we shall shortly see, that on the Orinoko the real jaguar of America sometimes leaps into the water to attack the Indians in their canoes."

I am personally acquainted with gentlemen who have hunted the jaguaret in Paraguay, and who describe it as a very courageous and powerful animal, of great activity, and highly dangerous when at bay. Both these species and the puma are rendered more formidable by the facility with which they can ascend trees. I have been assured by several friends, who have repeatedly hunted the tiger in India, that even this "most beautiful and cruel of beasts of prey," as it is termed by Linnæus, generally endeavours to escape from the hunters, unless hard pressed, or surprised in a situation from which retreat is difficult; and one gentleman informed me, that, on a shooting excursion, to his great horror he found himself without a companion in a small field, in which he espied a tiger watching him; that, finding retreat impossible, he advanced against the animal firmly, when it slowly retired, until he had an opportunity of dispatching it with his rifle.

Such instances show that there is no striking difference between the habits and courage of the beasts of prey of the Old and New Continents, as imagined by Buffon.

While naturalists have been so unjust to the *character* of the American animals of this genus, the forms of these quadrupeds have not been more fortunately delineated in our engravings. For instance; the figure of the black tiger in Buffon, and in his copyist Shaw, is so wretchedly drawn, and its limbs are so distorted, that not a trace of the genuine form is preserved; but it is considerably better given in the respectable work of Pennant. The figures of the jaguar and puma, in both the former works, are inaccurate in many respects, especially in the form of the heads, and in giving no idea of the fierce expression of the countenances. The figure of the ocelot, in Shaw, is an absolute caricature, and conveys no idea of the sprightly motions and strength of this beautiful miniature of the leopard.

These circumstances have induced me to lay before the society an account of a very beautiful jaguar from Paraguay, which was some time ago alive in Liverpool. When the animal arrived, it was in full health, and, though not fully grown, was of very formidable size and strength. The captain who brought it could venture to play with it, as it lay in one of the boats on deck, to which it was chained; but it had been familiarised to him from the time it was the size of a small dog. I did not venture to take measurements of it; but it appeared to be between six and seven feet in length (including the tail,) and to stand between two and three feet in height at the shoulder. The size of the fore-legs seemed very great in proportion to the bulk of the body, and especially of the hind-legs and rump of the animal. The ground-colour is bright fulvous; the fur is short, thick, and glossy, all over the body. It is variegated by long chain-like spots. A chain of such spots passes down the spine from the shoulders to the tail, which consists chiefly of single spots; but some of them are double. On each side of this chain are several rows of open spots, formed by a glossy border of black, including one, or more spots of the same colour. As they descend the sides of the animal, these borders become interrupted, and present the appearance of clusters of four irregular oblong spots, with occasionally one or more small, central dots. Viewed from above, the back has no inconsiderable resemblance to the markings of the shells of some species of tortoise, from the peculiar arrangement of the colours, and the equality of the spaces between each cluster of spots. The face, sides of the neck, and both sides of the legs, are thickly studded with small black spots. The ground-colour of the lower part of

the body and inside of the thighs is dull-yellowish white; but the belly is spotted with large, black, irregular marks.

The hair of the tail is not glossy: its upper part is marked with a zigzag pattern, and its lower part is annulated with two or three broad blackish-brown rings, separated by dull yellow stripes. There are two distinct sets of vibrissæ; the first of which are the longest, and are placed two or three inches before the scanty hairs of the other set. The teeth are very large and strong. The whole animal had an appearance of activity and strength, which fully confirmed the accounts of its prowess collected by Humboldt.

### Felis Puma.

For this animal I would propose the following specific character, which appears necessary to distinguish it completely from *Felis unicolor*, described by me in the third volume of the Society's Memoirs.

Felis, *corpore dilutè badio; auribus nigris; caudâ claviformi, apice nigricanti.*

Cat, *with a light-bay body; black ears; a claviform tail, brownish-black at the tip.*

I had an opportunity of inspecting several skins of this animal, the property of Mr Edmonston, who had killed them in the interior of Demerary. None of them were without the marks indicated in the specific character. The whiskers of all arose from a dark coloured spot on the face. The blackish tip of the tail measured five inches; and, from the length and position of the hairs, made the extremity the thickest part of the tail, or gave it a claviform shape. One of these animals was a female, shot while searching for prey in a lofty tree: its whelp was at the bottom, feeding on a monkey, which had probably been killed by the mother. The young one was also shot. The body of the latter measured, from nose to tail, two feet, and the tail one foot one inch. The upper part of the body was not of an uniform colour like the dam, but it had three chains of blackish-brown spots along its back, with several scattered markings of the same colour on its sides, neck, and shoulders. The crown of the head had several obscure stripes; but the blackish spot at the roots of the vibrissæ, and the black backs of the ears, were very conspicuous. The lower part of the body, and the insides of the limbs, were of a dirty yellowish-grey, with dull brown bars. These marks disappear in the full-grown animal.

The largest of Mr Edmonston's specimens seemed an animal of prodigious power. It had a much larger head, in proportion to its size, than the figures of Buffon and Shaw; and its canine teeth were enormously large. The dimensions are as follow:

| | Feet. | Inch. |
|---|---|---|
| Length from nose to tail | 4 | 9 |
| —— of tail | 2 | 6 |
| Total length | 7 | 3 |
| Length of the head | 1 | 0 |
| Circumference of ditto | 1 | 9¼ |
| Length of the large canine teeth above the jaw | 0 | 1¼ |

*Liverpool, November* 1822.

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Art. LXV.—*On the detection of small quantities of Arsenic. In a letter to the Editor of the Annals of Philosophy.* By T. S. Traill, M. D., &c. [*Annals of Philos.*]

Your very interesting paper in the last number of the *Annals*, on the tests of arsenic, followed by an application to examine the contents of a stomach in which I discovered that deleterious substance, has drawn my thoughts to a subject which has often engaged my attention, from having been repeatedly called on to determine the nature of substances found in the alimentary canal of persons who have died under suspicious circumstances.

Your remarks on the application of the usual liquid tests are extremely just, and in my opinion, leave nothing further to be derived on the subject; but I have long been aware of the erroneous opinion entertained by authors of reputation, respecting the inutility of attempting to reduce to the metallic state, portions of white arsenic considerably less than a grain. Even by the common process, I have often succeeded in reducing to a perfect metallic film much less than half a grain of the arsenious acid; although it was the opinion of the celebrated Black, that one grain, and of Dr Bostock that three-quarters of a grain, are the smallest quantities from which we can hope distinct results by this process. I may here notice the importance of attempting the reduction

in all cases of suspected poison; for it has several times happened, that I have been able to show the presence of arsenic in cases where it has been supposed absent, because the white powder gave no alliaceous smell when thrown on a *live coal.* This method of operating should be abandoned; because the carbonic acid and sulphurous vapour from the coal disguise the peculiar odour of the arsenic; and much of the powder is probably raised in vapour without reduction, and consequently without giving out the alliaceous smell.

The trouble and delay of preparing a coated tube induced me long ago to attempt the reduction in a thin glass tube, with the naked fire, or with the blow-pipe; and the facility thus obtained made the reduction much less irksome. But your happy suggestion of the spirit-lamp has rendered the process still more easy—even elegant; and has enabled me to produce unequivocal metallization of arsenic from portions of the white powder far more minute than what has been mentioned—a circumstance of no small moment, as it affords the most unexceptionable test of what may affect the life of a human being.

The following simple appartus is all that is requisite; and after many trials, I gave the process about to be described, the preference.

Take a thin glass tube 2¼ inches long, and about 0.4 inch wide, closed at one end, with a slightly dilated mouth; like the common test tubes of the blow-pipe apparatus. A piece of copper wire, loosely twisted round its upper end, serves to attach it to any convenient support, at an angle of about 30° or 40°; while the flame of a spirit-lamp is applied to the closed end of the tube containing the mixture to be reduced.

I employ either the black flux, or a little subcarbonate of soda or potash mixed with charcoal powder. Either of these should be at least equal to thrice the weight of the substance to be ascertained; but a small excess of them is safer than the opposite extreme. Where the quantity is not very minute, it is unnecessary to grind the whole ingredients together, but mixing them on a piece of glass, or of writing paper, with the point of a knife, before they are introduced into the tube, will be sufficient. The tube should be dry and clean; and its orifice may be slightly stopped with paper. Where the quantities are very minute, I usually grind them in an agate mortar; but as every such manual operation, however simple, is embarrassing to those little

habituated to experiment, I consider it very useful to simplify the process by omitting this operation, and substituting an addition of charcoal powder, after the mixture is introduced into the tube. The flame of a spirit-lamp will speedily raise the closed end of the tube to a dull red heat, and in less than two minutes, a shining metallic crust will invest the upper side of the inclined tube, about half an inch from the flame. When the tube is cold, I shake out the loose materials from the bottom, and then scrape off the metallic crust from its sides with a knife. This saves the tube for further use, a matter of some consequence in the country. By this process I have reduced less than one-eighth, and even than one-tenth of a grain of arsenious acid, or, as it is sometimes called, the white oxide, to the metallic state. The metallic crust afforded by one-tenth of a grain, was perfectly distinct to the naked eye, and very conspicuous when a lens was employed. The scrapings of the tube in this case glistened strongly, with a metallic lustre, on the clean blade of the knife; and when six different portions of this substance were projected on a poker, heated to a dull red, each gave a distinctly visible white smoke, and decided alliaceous odour; although each portion could only have contained about 1-78th of a grain of the metal.

I may add, that if a clean knife be held in the fume, a portion of a white powder will be condensed on the blade, even from the most minute portion of arsenic which I have thus volatilized.

## Art. LXVI.—*On the action of Platinum on Mixtures of Oxygen, Hydrogen, and other Gases.* [*Jour. Roy. Instit.*]

A singular discovery has been lately noticed in the scientific Journals of Europe, made by M. Dœbereiner. He has found that upon subjecting a preparation of platinum called usually platinum sponge to a stream of hydrogen gas, that the metal becomes ignited and that the gas generally inflames. The following article contains a condensed account of the observations which have been made with relation to this subject. [*Ed. B. J.*]

The preparation of platinum observed by Mr E. Davy, which ignites in contact with the vapour of alcohol, is well

known. M. Dœbereiner, by precipitating a solution of platinum by sulphuretted hydrogen, and exposing the dry precipitate to the air for a few weeks, obtained an oxidized sulphuret, having similar properties, and further ascertained that both these substances enable the alcohol to attract oxygen gas, producing acetic acid and water at the same time with the phenomena of ignition before referred to. By further experiments, it was ascertained that neither oxygen nor carbonic acid gas was absorbed by these two substances, but that every inflammable gas was; and 100 grains of the protoxide of platinum (Mr Davy's substance,) absorbed from 15 to 20 cubic inches of hydrogen gas with ignition of the substance, and also of the hydrogen, if previously mixed with air or oxygen. The preparation of platinum charged with hydrogen readily attracts as much oxygen as will combine with the hydrogen it contains, so that air being admitted, the oxygen instantly disappears; and even ammonia is formed, if there be not enough oxygen for the hydrogen in the platinum. The platinum immediately reduced, loses some of the properties it before possessed, but retains the power of determining the combination of hydrogen gas with oxygen gas, and with the evolution of so much heat, as, if the experiment be made properly, to ignite the platinum. M. Dœbereiner immediately concluded that the platinum obtained by heating the ammonia-muriate would have the same effect, and found his expectations confirmed by experiment. This experiment was made July 27, 1823.

M. Dœbereiner considers the phenomenon as an electric one, and that the hydrogen and platinum form a voltaic combination, in which the former represents the zinc. Another remarkable result was obtained with the oxidized sulphuret of platinum. Placed in contact with carbonic oxide, the gas diminished to one half, and became carbonic acid; hence it is decarbonized by the solid substance. In a supplement to the paper just abstracted, in which M. Dœbereiner describes the mode of making the experiment, as we have stated, by a jet of hydrogen, he mentions, also, that he had applied it to the construction of a new apparatus for procuring fire.

In a further communication to the public,* on this subject, M. Dœbereiner says, that the energy of hydrogen is so much increased by the presence of platinum in powder, that it will in a few minutes completely separate one part of

* Annales de Chimie, xxiv. 91. Bib. Univ. xxiv. 54.

oxygen from 99 of nitrogen, an effect which the strongest electrical spark will not produce. In these experiments platinum in powder is mixed with potter's clay, moistened, and made into small balls, about as large as a pea; these are dried and then heated to redness. One of these balls weighing from 2 to 6 grains, will convert any quantity of detonating gas into water, and may be employed above a thousand times, if dried carefully after each operation. The compound gases, containing hydrogen, do not combine with oxygen, when in contact with platinum. A jet of hydrogen on the platinum, precipitated by zinc from a solution, made it red hot, with a crackling noise and sparks; this powder is a mixture of platinum and its oxide, and converts alcohol, when oxygen is present, into acetic acid. Nickel prepared from the oxalate, has the property of converting oxygen and hydrogen gases slowly into water.

MM. Dulong and Thenard†, have verified the experiment of the ignition of platinum by a jet of hydrogen, and have added some other facts on the same subject. They remarked, as M. Dœbereiner had done, that, introduced into a mixture of oxygen and hydrogen, it determined the combination of the gases sometimes with ignition; that the platinum, strongly calcined, loses the property of becoming incandescent, but still slowly causes condensation; that finely divided platinum, obtained by other means, or wires, or laminæ, had no action at common temperatures, but that very thin leaf platinum crumpled up together acted instantly, although the same leaf rolled round a cylinder of glass, or suspended freely in the gases, had no action; but the leaves, wires, powder and plates, all acted slowly at temperatures between 400° and 572° F. Palladium in thin pieces acted at an elevated temperature, as well as platinum of the same thickness. Rhodium caused the formation of water at about 464° F. Gold and silver, in leaf, acted at a temperature somewhat under that of boiling mercury.

Carbonic oxide and oxygen form carbonic acid; nitrous gas is decomposed by hydrogen at the common temperature, by contact with spongy platinum, and a mixture of olefiant gas, with sufficient oxygen is changed into water and carbonic acid at 572° F.

These philosophers then observe, that certain metals have the property of decomposing ammonia, without absorbing

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† Annales de Chimie, xxiii. 440.

either of its elements, at a temperature at which the ammonia by itself would be quite unchanged; 150 grains of iron wire are thus sufficient for decomposing nearly the whole of a rapid current of ammoniacal gas, continued for 8 or 10 hours, whilst thrice as much platinum wire does not produce a like effect, even at a much higher temperature. These results depend, perhaps, on the same causes which make gold and silver effectual in combining oxygen and hydrogen at 572° F., massive platinum at 518° F., and spongy platinum at common temperatures. Now as iron so well separates the elements of ammonia, and scarcely at all effects the combination of hydrogen with oxygen, whilst with platinum it is the reverse; the authors are induced to suppose that some gases tend to combine under the influence of metals, and others to separate, the effect varying with the nature of each; but they refrain from offering conjectures until supported by experiments.

MM. Dulong and Thenard, have also ascertained that spongy palladium will inflame hydrogen as platinum does; that iridium in the same form became hot and produced water; that cobalt and nickel in masses, cause the gases to combine at about 300° F.; that cold spongy platinum formed water and ammonia, with nitrous gas and hydrogen; and acted also on mixed hydrogen and nitrous oxide gases.

Mr W. Herapath* has made experiments on this subject, most of which, being of a similar nature to some of those already described, we omit to specify. His attention was particularly directed to the temperature at which the effect first began to take place, and he states, as the results of his experiments on this point, that if the gases have a temperature of 55°, the platinum requires a temperature so high as 98° to cause them to unite.

Mr Garden, of Oxford Street, has also experimented on this subject†, and has found, that the black powder, consisting of iridium and osmium, left when crude platinum is digested in nitro-muriatic acid, if heated red hot and then suffered to cool, acts as well as spongy platinum itself. He also ascertained that a jet of hydrogen cooled to 32°, if thrown upon spongy platinum cooled also to 32°, quickly heated it to whiteness, and became inflamed, a result which contradicts Mr Herapath's statement, and shows that the limit

* Philosophical Mag. lxii. 28.

† Annals Phil. N. S. vi. 466.

of temperature at which spongy platinum ceases to act on mixed oxygen and hydrogen gas has not yet been attained.

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To the preceding we annex the following, from the Philos. Mag.:

*Dœbereiner's Eudiometer.*

"The very remarkable discovery of Professor Dœbereiner, concerning the relation of the metallic powder of platinum to a gaseous mixture of hydrogen and oxygen," observes Prof. Gmelin, "I found confirmed in a splendid, but at the same time in a dangerous manner. I caused a few cubic inches of hydrogen gas to enter into an eudiometer two inches in width, and the glass of which was one line in thickness; and then brought the platinum-powder, wrapped up in white blotting paper, through the quicksilver, into contact with the gas. I then caused oxygen gas to enter into the eudiometer, and when but few bubbles had ascended, a terrible explosion took place, which shivered the glass into a thousand pieces, which were thrown about to the distance of ten feet. It is remarkable that neither myself nor Prof. Bohnenberger, who stood by, was in the least injured. I do not consider it superfluous to communicate this experiment to you, since it proves that great caution is required in attempting it. In Prof. Dœbereiner's experiments, no explosion appears to have taken place. I afterwards made the experiment with hydrogen and atmospheric air, and found that a considerable diminution of volume followed; but it appeared at the same time, that much of the oxygen remained; for the residue still exploded strongly by means of the electric spark; and a considerable diminution of volume again took place. It appears therefore that this method will not answer the purpose of an eudiometer.

"The further results I obtained are as follows:

1. It is indifferent whether the hydrogen be first brought into the vessel, the platinum powder afterwards, and then the atmospheric air; or whether the hydrogen gas and the atmospheric air be first mixed in the vessel, and the platinum powder then introduced.

2. Much humidity prevents the absorption.

3. Silver dust (obtained from nitrate of silver by copper) and gold dust (obtained from muriate of gold, precipitated

by iron, and purified by hot muriatic acid and water) do not produce the least effect not even with oxygen gas."

The above is translated from a letter of Prof. Gmelin to Prof. Schweigger, published in the October number of the *Neues Jour. für Chemie, &c.* of the latter, who makes the following remark on Prof. Gmelin's conclusion as to the inapplicability of Dœbereiner's discovery to eudiometrical purposes:—"Under what conditions this may notwithstanding be the case, will be seen in our next, in which will appear an account of the proceedings of the German explorers of nature, to whom, on the 20th of September, Prof. Dœbereiner communicated his remarks and experiments."

From Schweigger's Journal for November, we accordingly extract the following:—"At a meeting of the Society of the Explorers of Nature, held on the 20th of September, 1823, Prof. Dœbereiner fulfilled the promise he made at the first meeting, viz.: to communicate something more respecting his new and important discovery, so far as it is applicable to eudiometry, and to exhibit it by experiments.

"The platinum is kneaded up with clay into small balls, which are then brought to a white heat before the blow-pipe. If such a ball, suspended by a platinum wire, is dipped into an open glass vessel filled with hydrogen and oxygen, the ball rapidly becomes red-hot; during which a cloud of vapour forms itself around it; it then becomes white-hot, and the explosion immediately takes place. Such balls answer best for eudiometrical experiments made over quicksilver. The decomposition would certainly not be completely effected if the platinum powder, moistened by the water which is formed, ceased to remain hot. But how easy is it in such a case to let another ball be carried through the quicksilver, in case the first is not sufficient!"*

* The platinum sponge is obtained by precipitating the platinum from its solution, by muriate of ammonia and subjecting the precipitate to a low red heat. In repeating these experiments we have found that the same portion of the sponge may be made use of many times. The experiment is very striking when performed with Dr Hare's blow-pipe; the stream of hydrogen being first directed upon the platinum, which immediately becomes red-hot, and the hydrogen inflames; on admitting the oxygen a slight explosion occurs, and the two gases burn with great splendour. We have repeatedly caused the inflammation of the hydrogen when the platinum was at the distance of ten or twelve inches from the jet.

J. W. W.

**Art. LXVII.**—*An account of the opening of two Mummies belonging to M. Cailliard.* [*Translated from the Revue Encyclopedique of January* 1824.]

Among the valuable objects which M. Cailliard brought with him from Egypt in his last voyage, and which form a part of his rich Egyptian collection, antiquaries and the curious have distinguished a fine mummy remarkable for its size and weight; on the head is a crown formed of plates and buds of gilded copper, resembling the leaves and fruit of the young olive tree. It is still more deserving the attention of the learned, on account of the case in which it is enclosed. On the bottom is painted a zodiack, the figures of which resemble those of the zodiack of Denderah, and on the top of the case is a small Greek inscription which is nearly effaced; the name of Petemenon on the head is also legible in Greek on the margin of a small hieroglyphical papyrus, which appears to have been placed among the exterior bandages of the mummy. In addition to this the head and feet are of great size. So many new and striking circumstances render this mummy one of the most valuable objects of antiquity which has yet been discovered, and led to the expectation that the opening of it would bring to light manuscripts and other more important discoveries; its great weight also induced the belief that it enclosed some metallic matter.

After hesitating for a long time what plan to adopt, M. Cailliard very generously acceded to the wishes of the learned and curious. On the 30th of November, he proceeded to open the mummy in his museum in the presence of a great number of persons of distinction, among whom were Baron Humboldt, Baron Larrey, M. Denon, M. Abel Remusat, &c. &c.

The lively curiosity this spectacle excited, which was new to most of those present, and the interest they evinced, merit a full detail of the operation. They began by carefully weighing and measuring the mummy, together with all its coverings. Its weight somewhat exceeded 231 pounds. Its length was 6 feet 4 inches. * * * *

After this operation they disengaged a narrow band which confined around the body a cloth covered with paintings and hieroglyphics, with ornaments not very common in Egypt: under this were many coarse but firm cloths, forming the

first envelope, which was easily raised. The second envelope was confined round the neck by a knot which sailor's call a carrick bend; under this were a number of bands of rather finer cloth and three small napkins or scarfs laid in small folds. The third envelope, arranged in the same manner, and formed of small bands of napkins and long strips, served to support the sides. In the fourth envelope they found very large bands of old coarse linen; four Egyptian tunics without sleeves and unsewn, so as to be applied close to the body: the large piece enveloping the whole body was fixed by a black bitumen with thick layers of the same about the head and feet. These tunics are about 3 feet 8 inches wide by 3 feet long, with an opening of 10 inches for the head and two similar ones for the arms. The fifth envelope presented bands placed lengthwise, connecting the head and feet; transverse bands of four large pieces encompassed the body: all of which were tolerably fine.

The sixth envelope was formed of, 1. transverse bands of a yellow tint from having been penetrated by or steeped in a bitumen of that colour: 2. of 15 pieces of similar cloth.

The seventh and last envelope was penetrated with black bitumen, and formed six pieces adhering together by means of this balsam; after which there remained only a thin layer to remove in order to arrive at the skin.

They observed as usual, that the toes were wrapped separately, the arms and hands were extended along the thighs; the subject was a male, and appeared to be at most about 45 or 50 years of age. The length of the body was 5 feet 9 inches 2-10ths.

The chest and one part of the abdomen were gilded irregularly upon the epidermis.

The abdomen being opened, a great quantity of black balsam was found in it; but it was singular that no manuscript was found between the thighs or under the arms; and all along the legs were large pieces of the black balsam of fine quality. The unfolding of these innumerable bands and envelopes occupied nearly three hours, although it was done with sharp instruments; but this long operation discovered nothing but the balsam and the cloths, and the expectations which had been excited were not realized.

However, M. Cailliard was not discouraged, and a few days after, he took off the layer of linen and bitumen which was in contact with the skin. He then discovered 7 or 8

thicknesses of very fine cloth. Many parts of the arms were gilded in places like the breast.

The hands were long and well preserved, the fingers were well shaped and even plump; the ears were perfect, and the nose, (from the brain having been extracted through the nasal fossæ) was a little deformed. It was remarked that the profile was straighter, and the forehead less inclined than in common mummies; the hair was perfectly preserved, fine, and a little frizzled. On the left side was an opening five inches in diameter, through which the balsam was introduced in place of the viscera.

But what in some degree indemnified M. Cailliaud for his almost fruitless labours, was that on removing the last cloth from the face, he discovered under each of the eyes and upon the cheek bones a plate of gold representing the figure of an eye with the eyelashes; over the mouth he found another plate of gold somewhat in shape of a tongue and placed perpendicularly over the joining of the lips, which were perfectly closed: thus as a double singularity (*une double singularité*) of which we have no previous example. It is remarkable that, the form of the eye is a conventional sign and not the resemblance of the natural object. This image may have related to the death of the individual, or it may have indicated a consecration to Osiris, of which the eye was an emblem; in the first case, we may make a plausible though premature conjecture. The plate of gold found over the mouth, recalls to mind the leaf of the *persea*, a tree consecrated to Isis, among the Egyptians, for they say she resembles a tongue. We shall however, not offer any opinion. On closely examining the linen of the mummy we found a tunic patched with pieces neatly put together; another having many characters written with ink; at last a fine scarf trimmed with fringes and silver lace, marked with the letters A. M. initials of the Greek name of the person: this mark was embroidered.

The second mummy opened by M. Cailliaud had a particular interest from the manner in which it was embalmed, which differed from all those which are known: there did not enter into the preparation either bitumen, mineral alkali or any salt. The bands and the cloths were rolled about the body without any adherence; so that they could be taken up with great facility, but between each fold of the cloths was found a thick layer of the dust of wood or bark, the object of which undoubtedly was to absorb any moisture, and this it effectually did. The body also contained a great

quantity of this dust instead of bitumen. It is worthy of remark that the flesh was perfectly preserved by this simple process. The colour of the skin was yellow instead of black. The ears and the cartilage of the nose were very flexible; they received the impression of the finger; and even the white of the eye could be found. The person thus embalmed was an old man. There were found three little straps or stoles crossed round the neck: they were either of common leather or of brown morocco, marked with hieroglyphics, resembling the impressions made by the application of a dry stamp. This sort of figures is now known in Paris through M. Cailliaud who brought some of the same kind with him in 1819; (the editor of his first voyage had them engraved) but we are ignorant what place these bannerals occupied, whether on the mummies or elsewhere. One of these is in the form of a common spatula like the embroidery under the shoulders upon the Egyptian tunic discovered by Gen. Regnier, which is deposited in the library of the Institute.

M. Cailliaud possesses many other mummies in good preservation, among which we observed two that are enclosed in pasteboard cases, enriched with paintings, and sewed up on the back.

Art. LXVIII.—*Observations on the arguments adduced in support of Circular Sterns.* [*Edin. Phil. Journ.*]

Mr Knowles informs us*, that "the advantages derived from the circular sterns, may be classed under the following heads:

"1*st*, A considerable addition to the strength of the ships.

"2*d*, Safety to the people employed in them, both from the effects of a sea striking their sterns, and from shot fired by the enemy.

* *London Journal of Science*, No. xxviii. Art. vii.

"3d, The additional means afforded for *attack* or defence.

"4th, The improvement in the sailing qualities of the ships, by the removal of the quarter galleries."

The first of these advantages will we believe be readily acknowledged. Under the second head we are told that, "in sterns formed according to the old plan, the men on all the decks, excepting those in the lower gun-decks in ships of the Line, are exposed to the most destructive raking fire, their sterns being pervious even to a musket-ball." From this we might be led to conclude that ships' sides would be impervious at least to grape. But the quarter-deck bulwark of a frigate to which I did belong, (and which, during the war with America, was sent on that coast to cope with their large frigates,) was "*pervious even to a musket-ball.*"

We are informed, that "the guns can be run out in that part, pointed, elevated, or depressed, with as much facility, and in the same manner, that those are in the sides of ships." But we are not told, that as all the guns will recoil to a common centre, there will be little room for them to be worked, and that the men being so crowded together, "will be exposed to the most destructive raking fire." We are told, that "when an enemy's ship has laid upon the quarters of any vessel, it has technically been called" "the point of impunity." This is granted; and from the superiority of our tactics, &c., it is the position that we used generally to be able to take; but with the round stern, the fire of at least the aftermost gun on the broadside, when in that position, is entirely lost.

Our author goes on to say, that "Sir Robert Seppings has stated, in his letter before alluded to, that, according to the present disposition of the ports, a three-decked ship can bring at least ten guns to bear upon her assailant, a two-decker eight, and a frigate four." This can be no argument in favour of the curvilinear form, for it is the same number that ships with the old form could fire right aft.

"Their sea-going properties are improved, by the omission of quarter-galleries, which acted as a back-sail, when ships were going on a wind." This must be acknowledged; but what proportion do quarter-galleries bear to poops, which are now put on even to brigs?

That Sir Robert Seppings himself does not think the form perfect, may be proved by his having already twice altered the plan of the Vengeance, which is now building at Pembroke. Is it not a pity, that such extensive alterations

should be carried on, before the inventor's own ideas are matured upon the subject?

Mr Harvey mentions*, that "Sir Robert Seppings, in his first appendix to his able letter, has furnished above 120 examples of ships of different classes, the sterns of which have been made the subject of frequent and strong complaint by their respective commanders. To increase the importance of the documents, it is worthy of observation, that they have not been collected from any very limited portion of time, or when any particular feeling in favour of a change of form might have existed in the Navy; but during a period of nearly a quarter of a century." This says nothing more than that Sir Robert Seppings has ransacked the records of twenty-five years for examples. And although he tells us, that during this space of time he has been enabled to find 120, still he does not tell us how many instances, in the same space of time, he might have collected of ships being weak in the bows or elsewhere. And although 120 be in nearly the proportion of five a-year, still what is that in comparison to the number of vessels that were employed "through the trying services of a long and active war?"

Sir Robert, at p. 6. of his letter, very properly remarks, "that circular sterns are formed, and in all respects timbered and secured, in the same manner as the bow; and consequently equally well adapted to stand the shock of the sea." But though the strength may be equal, the form of the counters is by no means the same as the form of the bows near the surface of the water, which, in resisting the shock of the sea, is of equally great importance. But the upper part of the stern need not be so strong, for we seldom hear of the dead-lights of a frigate or line-of-battle ship being stove in. And in the instances brought forward in Mr Harvey's paper, the weakness is almost invariably occasioned by a tendency in the sides to separate. This being the case, I should think that the stern timbers above the counter, might be considerably smaller than those of the sides and bow. So great a weight being removed from the overhanging part of the counters, would make them comparatively stronger. The great danger to be apprehended from the effects of a sea striking vessels, is either when they broach to, or are brought by the lee; in both these cases the sea would

* *Edinburgh Philosophical Journal*, No. xiii. Art. 3.

strike them on the sides. In getting stern-way, the great danger to be apprehended is the loss of the rudder.

"The next point of view in which this important subject may be contemplated, is the consideration of the means which each form of stern affords for *attack* and defence." A comparison is here drawn between Men-of-war and Field-fortification. I cannot say I think this comparison holds good. But if it does, is it not a maxim in fortification, that no gun has its full effect, unless the parapet be at right angles with the object assailed? This, then, being the case, it can seldom happen that more than one gun on each deck, in the aft-part of the vessel, can have its full effect; and every body on board men-of-war knows the difficulty of preventing men from wooding their guns in training them. "In the retreat of admiral Cornwallis before the French fleet, they had no means but of firing right aft." In this case, of course, the after-guns of the broadside were put out of the stern-post; and with the round stern more could not have been done; for had the guns been brought from forward, the trim of the vessels would have been spoilt, and capture would have been the inevitable consequence. "Sir Robert" observes, "they were mutilated to such a degree, to enable them to apply their guns, that a refit of no small extent was necessary." This, I fear, would partially take place now; as of course the iron railings of the stern-walks must be removed; and there is a probability of fire lodging there, as well as the great danger of the ship's catching fire, if the gun that is intended to go through the quarter-gallery port, were not run out to its full extent, which, in the heat of action, is very liable to be the case.

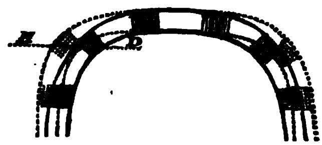
"In the event of future wars," observes Sir Robert, "an alteration in the form of the stern of ships of war, would in all probability be absolutely necessary, by which the guns may be worked with greater effect and facility, in consequence of the introduction of steam-vessels; and that America is firmly convinced that a system of attack, by this description of vessels, is not only practicable, but that it will also be destructive in its operations, is not to be doubted. Indeed," continues Sir Robert, "I have been told, from good authority, that they have lately well manned one of their frigates, given the command of her to a good officer, and directed an experiment to be tried, if a vessel propelled by steam could not, under any circumstances, lay on the quarter of the ship she attacked, and the result was completely in favour of the steam-vessel. If we inquire into the cause

of this failure, we shall undoubtedly find, that the frigate was incapable of defending her quarter, owing to the square form of her stern,—a circumstance which could not have taken place, had she possessed one of a circular form." This appears weighty, but I fear it is not so; for if the steam-vessel could, under any circumstances, lay on the quarter of the ship she attacked, she could, with equal ease, take up a position on the bow; and no sooner would her enemies' guns be transported from forward to aft, than she would take up a fresh position. If it be answered, that there are to be guns in all these parts, (which I believe is not to be the case,) the weight of the extreme will be so great, that I fear even Sir Robert Seppings' system of building will not be strong enough to withstand it. A vessel's sailing would be materially injured; she would be laboursome in the sea; and, as I before stated, the stern would be so crowded, that there would be an impossibility of working the guns. I remember trying, on board one of the round sterned frigates (whose name I forget) at Woolwich, what scope the guns would embrace; and so far from being able to take so great a range as is represented by the dotted lines in Mr Harvey's diagram, it would be difficult for the after-gun on the broadside to fight directly abeam; and I am perfectly convinced that it would be impossible to fire a gun through the quarter-gallery port, in the direction of *D H* in the following diagram. It may be observed, in inspecting the diagrams intended to illustrate Mr Harvey's arguments, that, in the representation of the square stern, the space is left that would be necessary for the size of the gun, and to prevent its being wooded. But some of the dotted lines in fig. 1. actually touch the bulwark. I should hardly conceive this to be a fair representation; nay, it almost looks like prejudice; of which both Mr Harvey and Mr Knowles complain in all those who are opposed to this system; yet is it not more likely that there should be many, (in a country already grateful for the many benefits Sir Robert Seppings has conferred on it,) equally prejudiced in favour of this method; and it must be remembered, that though many look with caution on innovations, there are still many others equally eager for novelties and fancied improvements.

The opinion of Mr Dupin is quoted by Mr Harvey. "Act contrary," says this enlightened author, "to what has hitherto been the practice; and if possible make the means of defence of that part most exposed ten times as great as it now is." This argument has not equal weight with us, as

the stern of a British man-of-war, is not the part most exposed.

Thus I am led to conclude, that the method of building is very good; but still that the stern should be as nearly square as this method of building will allow.



In the annexed sketch, the black lines represent the form as given by Mr Harvey, and the dotted lines the alterations which I venture to propose. It will here be seen that the after-gun on the broadside has its full effect. The gun at the salient has fully as great a range as the quarter-gallery gun on the round stern; and there will be more room for the men to fight their guns.

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Art. LXIX.—*Outlines of Oryctology. An Introduction to the study of Fossil Organic Remains; especially those found in the British Strata; intended to aid the Student in his Inquiries respecting the Nature of Fossils; and their connexion with the Formation of the Earth. With Illustrative Plates;* By James Parkinson, Fellow of the Royal College of Surgeons. M.G.S. and W.S. &c. &c. 8vo. pp. 346. (With ten plates.) Price 12*s.* London, 1822.—[*Eclectic Rev. January,* 1824.]

That our globe has, at some period of remote antiquity, suffered extensive changes and revolutions, there cannot arise the slightest doubt, independently altogether of the unquestionable record of the Deluge. The nature of these changes, however, and the manner in which they have been produced, can be inferred only from the monuments which the more indestructible parts of the Earth still exhibit; and these present to the naturalist and the antiquary the most interesting objects of research and contemplation. They connect the most minute observations with the most sublime and extended conceptions of the duration, magnitude, and infinite diversity of the works of creation, and place before us the infancy, if not the origin of our planet. The pursuit of this

branch of philosophy, particularly in its relations to the history of the Creation and of the Deluge, may, perhaps, incline us to view it with too much partiality; but we cannot look upon any department of human research as more interesting: there is no one that teems with more curious facts, more pleasing details, or more unexpected conclusions. On this, as on other branches of Natural History, much ridicule has been thrown by those who devote themselves to pursuits deemed more intellectual; yet, surely, the Antiquities of the Globe itself, are at least of as much importance as those of any of the particular nations who have inhabited its surface. In the ruins of Pompeii or of Gerasa, we may discover monuments of the power and grandeur of the Romans, and acquire some knowledge of their manner of life; but, in the Fossil remains of the quarries of Paris, the London basin, and the banks of the Ohio, we behold the diversified plans of the Creator of the world, and learn, where we cannot comprehend, to worship and adore Him.

In tracing the hand of God in those monuments which now remain of a former order of things, two methods have been adopted by naturalists. The one is, to follow, according to their relative antiquity, the arrangement of the rocks which compose the crust of the globe, and to consider the various organic remains which they contain. The want of sufficient data is an insuperable objection to this arrangement, although it is in other respects the most eligible. The only good classification of rocks that has been made with this view, is that of Werner, which it is by no means so free from exception as to warrant its general adoption. The other method is, to arrange organic remains according to the classes and orders of animals and vegetables from which they seem to have sprung; the arrangement which Mr Parkinson has adopted both in the work before us, and in his former splendid work, "The Organic Remains of a Former World." To humor the natural propensity which the mind has to ascend, rather than to descend in a scale, he begins with vegetable remains, and thence proceeds to consider the remains of Zoophytes, and the more perfect animals in their order. In this course we shall follow him, by abstracting and condensing the most interesting facts which he has collected.

The remains of vegetables are, perhaps, with the exception of shells and Zoophytes, the most numerous and extensive; specimens occurring of all the different natural orders, from the most delicate moss to the largest tree, and of almost

every degree of hardness which rocks are found to possess. As the species cannot, however, owing to the usual state of the parts, be classed according to any Botanical System, we may obtain clearer notions of this part of the subject, by considering them, as is partially done by Mr Parkinson, in a mineralogical point of view, according to the substances into which they are found converted.

Mr Parkinson characterizes the first stage of vegetable mineralization, by the term *Bituminous*. Wood, moss, and other vegetable productions, are changed into this state, not, apparently, by being penetrated with any thing like a petrifying solution, nor by being exposed to subterranean fire or heat, but by the presence of moisture, the exclusion of air, and their being compressed by superincumbent materials. Pressure alone, indeed, is adequate to the conversion of such productions into a substance of very great hardness; for, by artificial pressure, sphagna, byssi, and other soft mosses, have been brought to take a tolerable polish like the hard woods and marble. But when the change arising from pressure is modified by the presence of moisture and the exclusion of air, vegetable substances acquire very peculiar properties. They commonly preserve their original texture and appearance so perfectly that the particular tree or plant can be recognized. Even trees of great diameter are often changed to their very centre, while their leaves and the most delicate parts which are so changed, often preserve their texture uninjured. They are then found to resist the further action of water, and, when applied to useful purposes, to be almost impenetrable to it; but the water that may chance to be lodged among their minute interstices, they tenaciously retain. The bark is frequently unchanged, and, in the case of birch and some other trees, preserves its color and glossy, varnished appearance. They are in general very unfriendly to animal life, and are therefore indestructible by insects.

Wood and other vegetable productions in the different stages of bituminization, are found in peat-bogs, and at Bovey, Baly-castle, the Cape of Good Hope, and many other places. This is the Bovey coal of this country, and the *Suturbrand* of Iceland.

'This fossil wood,' says Mr Parkinson, 'may be said to pass into jet, which is found, especially in the neighbourhood of Whitby, in Yorkshire, in a state very nearly approximating to that of Bovey coal..... Jet is found in other situations, in a different form; resembling, in its shape and the markings of its surface,

parts of the branches and trunks of trees, but rarely possessing, internally, any marks of vegetable origin; a circumstance easily accounted for, if its previous softening be admitted.' p. 7.

The evidence for this transition, given by MM. Chaptal and Fourcroy, though omitted by our Author, is still more decisive. The latter mentions a specimen in which the one end was obviously wood but little changed, and the other pure jet. The former transmitted to the cabinet of Languedoc, several specimens which were ligneous externally, and perfect jet in the internal parts, distinctly exhibiting the transition of the one into the other. According to Chaptal also, there have been dug up at Montpelier, whole cart-loads of trees converted into jet; their original forms being so distinctly preserved, that he could often detect the species to which they belonged. He instances a walnut-tree completely converted into jet, found at Vachey, and a specimen of a beach similarly changed, from Bosrup in Scania. The same distinguished Author found a wooden pail, and also a wooden shovel, converted into pure jet. It would shew, we think, a very sceptical spirit, to hesitate in our decision, after such proofs, resting on the testimony of men so eminent in science.

The next class are those vegetable substances which may be more correctly said to be petrified, than the bituminated sorts. The stony materials which are most usually found to constitute petrifactions of this description, are flint, lime, and bituminous earth, of which the flint is by far the most common. There is often a new transmutation, or change of substance, in the fossil vegetable; but sometimes there is only an earthy impregnation. The stony matter, especially in flint, is commonly diffused through every part of the petrified mass, and seems to be ultimately united with their integral molecules. It has been principally formed in minute crystallizations, which, by mutual and regular apposition, have gradually formed a concrete substance;—a process plainly indicated by most of the specimens of this kind having an investiture or crust of extremely minute crystals, which are sometimes even visible on each fascicle of the fibres, and on the sides of interstices and cavities. Of wood so petrified, there seem to be two sorts, namely, that which has, and that which has not, undergone bituminous fermentation. The latter is usually in the state of rotten wood as to its texture, but its specific gravity soon undeceives those who suppose it to be wood of this kind.

That sort of petrified wood which partakes of the nature of Chalcedony, Jasper, Opal, or Pitchstone, has commonly a conchoidal fracture, a dark bituminous color within, although whitish externally, and gives sparks when struck with steel. The fibres are penetrated with the flinty matter, but no bituminous substance is found intermixed with the flint, or having a tendency to color it; and when the silex has got to the surface, or into a cavity, it often assumes a mammillated form, and becomes transparent. It is often bestudded with fine, small quartz crystals: some specimens seem to have been attacked by the teredo, and have the small holes filled with transparent flinty matter. Another sort is marked with colored delineations, like the compound pebbles called agates; this kind is usually more transparent than the former, and has a more vitreous lustre. Mr Parkinson is of opinion, that all jasperine minerals if they do not originate from vegetable materials, are closely connected with them. In some of them, we have distinctly seen the rings marking the annual growth of the original tree, and even the delicate wavings of the fibrillæ around what seems to have been a knot, or the off-going of a branch.

A not less interesting species of petrified vegetable productions than the flinty, is the calcareous. The formation of the latter, however, it is not so difficult to understand and explain. It is often carried on almost under the eye of the observer, in the case of the numerous calcareous springs, which, by depositing their lime, form incrustations on every thing they meet in their course. This process takes place to a great extent, at Matlock in Derbyshire, and at Tivoli in the vicinity of Rome: the waters at the latter place deposit lime and stone tuba so copiously, as to afford abundant materials for architectural purposes. It consequently happens, that whatever substances come in the way of these copious precipitates, are enclosed in the mass, and, if their texture will admit, are penetrated with it in all directions. The inhabitants of Matlock, as is well known, take advantage of this, to procure curious petrifactions of birds-nests with their eggs, wigs, besoms, and other things calculated to excite wonder by their conversion into stone by calcareous incrustation. In Italy and Peru, it has been turned to account in the making of busts, casts, and impressions of medals. It is worthy of remark, that, while the lower part of a stem of moss has been thus incrustated, the upper part sometimes has continued to vegetate, in the same way as mosses grow in peat-bogs after their roots have perished. Bota-

nists account for this from the singular nature of mosses, which grow from points in a great degree insulated with respect to the root.

The mineralization of vegetable substances by the metals, is a circumstance of frequent occurrence, and seems to take place much in the same way as the petrifactions already mentioned; namely, by the vegetable substance being penetrated with the metallic, either in a mechanical or a chemical manner. The first of these which merit our attention, have been called *pyrites*, from their often taking fire spontaneously when they come into contact with moisture. The woods which are properly denominated pyritical, have commonly a splendid metallic appearance, and are of a high specific gravity, while traces of their original texture are sometimes very obvious. Even the annual rings of the wood are occasionally found beautifully bestudded with the pyrites, whose surfaces often show a fine play of iridescent colours.

'In some specimens, in which the general appearance is that of bituminous wood, the metallic impregnation can only be detected by the weight of the fossil, and the blue or green hue on its surface. Cupreous wood in this state forms very beautiful specimens, displaying, not only on its surface, but in its substance, mingled with the charred wood, the most vivid blue and green colours, with patches of the carbonate in the state of malachite. The finest specimens of cupreous wood are obtained from the copper mines of Siberia.' p. 29.

In some specimens of a similar sort, the species of the tree so changed is often easily recognized. The birch and beech have been mentioned, of which the first often preserves its delicate white cuticle with its original texture. In some cases, the structure of rotten wood is very distinct, and also the different parts of the trees, as the stem, branches, twigs, leaves, and roots. The grassy turf of the soil also, with all the vegetable *exuviæ* which may be scattered upon it, are, on exposure to mineral springs, commonly rendered metallic. In Mexico, wood tin occurs, along with mammillated chalcedony. When it is recollected, that even in our herbaria, when every attention has been paid to the preservation of specimens, the ascertaining of distinctive characters, is often a matter of considerable difficulty, it may be easily imagined, that it will be a still harder task in those which have been converted into stony and metallic substances. Yet, the distinctive characters of species are often to be recognized in fossil vegetables; and mineralized wood has

been found, which proved to be beech, ash, willow, walnut, hazel, birch, pine, and many other kinds. The conjectures of fancy have been very fertile in discovering petrified remains of wood fashioned by the hand of man. It has been asserted, for instance, that the pieces of wood got from the Thames, are stakes which were driven into its bed by the Romans; when the fact is, that a stratum of piles quite similar is found to extend over a considerable part of the adjacent fields. Some classes and genera of vegetables appear to be more easily converted into stone than others. Thus we are told by Mr Wallis in his History of Northumberland, that the mosses and liverworts of a petrifying brook become stony, while the primroses and geraniums are quite untouched, and receive from it no foreign investiture or incrustation.

It is a curious fact with regard to the vegetable remains, or rather the impressions of vegetables, which are found in schistus, that when the *laminæ*, or the nodules containing them, have been split, the two plates of the stone display the same side of the leaf.

'The explanation of this curious circumstance, which long puzzled the oryctologists, is found in the vegetable matter, during its passing through the bituminous change, having become softened, and having filled its own mould with its melted and softened substance; the nodule, on being broken, shewing on one side the surface of the adherent bituminous cast, and, on the other, the correspondent mould.' p. 10.

The Zoophytes are the first species of living beings which are met with in rocks, when arranged according to their supposed relative antiquity. It is said, that, in the primitive rocks of Werner, no such remains exist, but that they begin to appear in transition rocks. However this may be, they are found in the newest depositions, even in alluvial soil: for example, in the Isle of Bute, considerably above the sea-mark, Professor Jameson found a small bed consisting chiefly of the *millepora polymorpha*. Among the least perfect of the zoophytes, Mr Parkinson places the genus sponge, concerning the nature of which many conjectures have been offered. In a note, he introduces the following interesting notice of this subject.

'Sir Humphrey Davy had procured iodine from several of the fuci and ulvæ, but not from the alkaline matter manufactured at Sicily, Spain, and the Roman States; nor did he find that the ashes of coral or of sponge appeared to contain it. From vari-

ous experiments, Dr Fyfe was enabled to conclude, that iodine was confined not only to the class cryptogamia, but to the marine productions of this class. Sponge being, however, considered to belong to the animal world, forms an apparent objection to this conclusion. But it must be remembered, that Linnæus was inclined to regard sponge as a vegetable substance, and to place it in the class cryptogamia, subdivision algæ aquaticæ; but was doubtful of the correctness of this arrangement. "May not the fact," Dr Fyfe observes, "that sponge contains iodine, be an argument in favour of the opinion of Linnæus, that this substance properly belongs to the vegetable world, class cryptogamia, from the plants of which iodine is obtained?" p. 36. *note.*

A still more recent investigation, however, has discovered iodine in medusæ and the polypi known by the name of animal flowers; which is, we think, quite conclusive, so far as this argument goes, that sponge is *not* a vegetable, but an animal substance.

A singular circumstance was observed by Mr Parkinson in a tubiporite limestone which he procured from Mendip; namely, the tubes were filled with flint, which took a polish. Does this give countenance to the conversion of animal remains of a calcareous kind into flint, as maintained by Linnæus and others? We believe that, in the present state of our knowledge, it is wholly inexplicable. Fossil tubiporæ indeed, like other organic remains, are seldom, perhaps never found in a recent state; and some of them are very unlike any thing which our seas now exhibit. Of this we have a fine example in the catenulata or chain-coral, the small tubes of which, when a horizontal section of them is made, appear in beautiful waived lines formed by the extremities of the tubes like the links of a chain: these waivings frequently approaching or coming into contact with one another, and then receding again, resemble very much the connected mesh-work of a net, or a retiform plexus of lymphatic vessels. In other tubiporites, there is a curious communication of the pipes by smaller tubes radiating from the larger ones, and passing through their contiguous plates of junction.

Some of the madreporites are flattened so as to indicate that they had suffered external compression; but the hardiness of their recent encasement previous to any thing like petrifaction, precludes that supposition. A few rare specimens are composed of transparent sparry limestone, and some have figures which the imagination easily construes

into the horns of goats and other animals, the remains of fungi and plants of that sort. These circumstances render a scientific arrangement of them a work of great difficulty, as the labours of their minute architects seem at times to have been modelled by whim and caprice, more than by any instinctive or circumstantial plan of operations. We cannot, however, judge accurately of this, on account of our deficient knowledge of the circumstances which might expedite or retard their work, and make them change their vertical direction to a sloping or a horizontal one. When we consider the singular wavings and convolutions of the starry tubes in the chain-coral and in the brain-stone, we shall not be surprised at the near resemblance which another species has to a honey-comb; an appearance which has given rise to the descriptions we find in the older authors, of petrified honey-combs. In a specimen of this kind from Mendit, Mr Parkinson found it completely converted into calcareous spar. Not the least remarkable of these madreporites, is that found in Wales, with columnar tubuli, having five, six, or seven angles, and exhibiting a fine miniature representation of the columnar basalt of Staffa and the Giant's Causeway, when viewed in an upright position; but, when a transverse section is made and polished, the tops of those columns appear like the webs of the field spider, being striated like the threads of those webs, both in radii and concentric circles.

But none of these 'medals of a former world,' as Bergman happily designates fossil remains, are nearly so singular and extraordinary as those which have been called Encrinites and Pentacrinites, upon the history of which, Mr Miller has recently published a scientific and splendid work. In these animals, nature seems to have concentrated so many wonders, that we are compelled to gaze on them with admiration, while the mind is overpowered on contemplating the diversified forms which animated life has assumed. The trunks and limbs of these zoophytes are formed of osseous pieces whose surfaces of articulation with one another are marked with the resemblance of flowers or stars. When these bony pieces are examined with a magnifier, it appears obvious, that their mutual articulation arises from the reception of the striated eminences of the one, into corresponding depressions in the other. These markings have been erroneously asserted by Rosinus, to continue throughout the substance of the tubes; for, on rubbing them down, few of the markings can be traced beyond the surface; but the surfaces

often approximate so near to each other, that one may be mistaken for another. The lily encrinite, or stone lily, may be selected in order to give a general idea of these extraordinary fossils.

The genus to which the stone lily belongs, is characterized by pentagonal, cylindrical, or oval vertebræ, with radiated articulating surfaces, composing a trunk which supports a pelvis, whence proceed five arms terminating in fingers and numerous tentacula. The lily encrinite has its arms terminating in a hand with two fingers furnished with numerous tentacula, the whole folding up in the form of a closed lily. The number of the bones in this fossil zoophyte almost exceed belief. Mr Parkinson enumerates 26,680; namely, the bones of the pelvis, 20; six bones in each of the ten arms, 60; forty in each of the twenty fingers, 800; thirty tentacula proceeding from each of the six bones in each of the ten arms, 1800; thirty tentacula from each of the 800 bones of the fingers, 24,000. In all these ossiculæ, Rosinus detected foramina or sinuses fitted for the reception of nerves or vessels, and all of them are nearly tubular, through which perhaps muscles might pass. Be this as it may, the animal must have been capable of a very varied motion in many directions; and provision is wisely made at the articulations, to prevent dislocation. The remains of this order of zoophytes are very numerous in many places, and are always contained in limestone, but commonly in a very shattered and mutilated state. Besides the stone lily, there are numerous other species, most of which are found in England. By far the best account of them is to be found in Miller's Natural History of the Crinoidea, lately published. Mr Miller has given a new arrangement of the genera and species, part of which Mr Parkinson has inserted.

Our limits will not admit of our following the Author through his observations on the higher species of fossil remains. Those of birds and insects are very rare; fossil fish are much more numerous. Among the quadrupeds, the *sauri* (lizard order) are very frequently occurring. On the recognized law laid down by Geologists, that few or none of the fossil species have any recent analogue, it might have been inferred, that no remains of man would be found petrified or embedded in rocks or strata. The bones formerly talked of as those of giants, are, by the more accurate researches of modern anatomy, found to belong to the mammoth, the rhinoceros, the elephant, &c. of the antediluvian world.

There are only two genuine human fossils at present known to exist, both from the Island of Guadaloupe. The one is in the British Museum, and is thought to be that of a female. The other has been received at Paris within the last few months. At the Peace, M. Donzelot, the Governor, was directed by the French Minister of the Marine to send this interesting fossil, which is, according to the description of Cuvier, more perfect than the one in the British Museum. It wants the cranium, but the greater part of the upper jaw, with some teeth, is preserved. The rest of the skeleton is in a bent position,—almost that of a semi-circle. It was quite hidden in the calcareous stone; but the bones had suffered no change, possessing their gelatinous animal matter and their inflammability. The stone contains besides, well preserved specimens of both sea and land shells still common in the island, a fact which proves that the skeleton is recent.

The fossil bones found in caverns, form a distinct class of phenomena. The discovery of a den of hyenas at Kirkdale near Kirby Moorside in Yorkshire, in the summer of 1821, has given rise to a controversy between Professor Buckland and Mr Penn, to which we shall probably have occasion to advert in a future Number. The present work keeps clear of theoretic speculation, the Author's object being to furnish a useful vade-mecum for the student who is desirous of being able to detect the specific character of fossil substances, and to arrange them under their appropriate genera. Mr Parkinson concludes his interesting little work with the following most appropriate and pious reflections:

'We cannot quit these monuments of former worlds without alluding to the incontrovertible evidence they present, of the exercise of Almighty Power and of the perpetual influence of a Divine Providence. The world is seen, in its formation and continuance, constantly under the Providence of Almighty God, without whose knowledge not one sparrow falls to the ground.

'Under these impressions, we view the results of these several changes and creations as manifesting the prescience, the power, and the benevolence of our great Creator. The general form of the earth's surface, varied by the distribution of hills and valleys, and of land and water; the prodigious accumulations of coal derived from the vegetables of a former creation, with the accompanying slates and schists; the useful, durable, and often beautiful, encrinital and shelly limestones; the immense formations of chalk and flint, and the various series of clays: all demonstrate a careful provision for the wants of man.

The several breaks and faults in the stratified masses, and the various inclinations of the strata, as well as the vast abruptions by which these several substances are brought to the hand of man, may be regarded as most beneficent provisions resulting from catastrophes too vast and tremendous for human intellect to comprehend.

'From these several creations, it appears that beings have proceeded, gradually increasing in superiority, from testaceous animals to reptiles, marine and fresh water amphibia, quadrupeds, and lastly to man, who, in his turn, is destined, with the earth he inhabits, to pass away, and be succeeded by a new heaven and a new earth.'

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Art. LXIX.—*Account of the Hybernation of the Snail (Cochlea Pomatia) and of some other circumstances connected with the Physiology of that animal.* Translated and abridged from "Memoire Physiologique sur le Colimacon, par B. Gaspard, M. D."* (*Magendie Journal de Physiologie Experimental and Pathologique.*) [J. W.]

Several ancient writers among whom are Aristotle, Dioscorides, and Pliny have spoken of the state of torpor in which snails pass the winter, but did not appear to entertain very exact ideas of the nature of that state. In our own times those naturalists, who have given the history of these animals, have been hardly more precise or explicit.

It is the object of the following paper, to state such facts and observations, the result of the personal experience of M. Gaspard, as will contribute to supply this deficiency in the natural history of the animal.

In temperate climates at the commencement of the cold weather in autumn, that is, about the beginning of October, a little earlier in mountainous districts, but a little later in the plains, snails begin to grow indolent, sluggish and inactive; they cease to move about, lose their appetite, and gather together into little companies, around hillocks and ditches, among bushes, and near hedges. After ceasing for a day or two to take any nourishment, and evacuating completely the intestinal canal, they conceal themselves under the moss or dried leaves and grass. Each individual then digs in the earth a convenient cavity, in which it places itself in such a

manner, that the aperture of its shell shall be directed upwards. It then completely retires into the interior of its habitation, and proceeds to fabricate from its tenacious slime, a soft silky membrane, which is stretched across the external opening of the shell, and thus secludes the animal entirely from the influence of external objects. On the internal surface of this membrane is next deposited a white liquid, which immediately hardens like plaster of Paris, and forms a solid barrier of the thickness of half a line; this is again lined on the inside by a silky membrane stronger than the first. The snail then retreats farther into its shell, by throwing out a portion of the air which it yet retains in its pulmonary organs, and makes a second partition, which is however, wholly of a membraneous structure. It goes on thus retreating farther and farther, making at each remove a new and distinct partition, so that in some instances it has been found that no less than six of these successive partitions have been constructed.

These phenomena were observed to take place in a very large number of subjects preserved and confined for that particular purpose; and the course taken by the animal, after its complete seclusion was ascertained by opening and examining a great many individuals in the successive stages of their labors. The whole process occupies in each snail, about two or three days; but they do not all complete it, till the beginning of November. After this time they are no longer to be found abroad, except a few which are prevented from hybernating in consequence of weakness or sickness, and are consequently killed by the earliest frosts. The depth at which they bury themselves in the earth depends upon the degree of facility with which the soil may be penetrated. They generally are found collected together by the side of or upon one another, as is the case with frogs, serpents, vipers, leeches, &c. If from any accident, the orifice of the shell is not placed exactly horizontally, it often happens that the calcareous liquid, before hardening, flows toward the part which is lowest and forms an irregular and imperfect operculum. It appears also to be the fact, that the interior membranous partitions are more numerous at the end, than at the beginning of winter, and more numerous also in mountainous than in plain countries.

In this state of torpor the snail generally passes six months, and does not, if left to itself, quit its habitation until the spring is somewhat advanced. If however it is disturbed and exposed to a certain degree of moisture, the influence of

which on its system will be hereafter pointed out, it issues from its shell and moves about from place to place. If exposed to a temperature of from 58° to 65° F. and supplied with food, it eats, recovers its colour and freshness, but in about eight days returns to the torpid state, after taking the measures of security which have already been described. If the temperature is lower, as from 50° to 55°, it eats little, and after some time retires into its hole in the earth; but the barrier which it provides at the entrance of its shell is thin, flexible, and containing but little calcareous matter. At still lower temperatures no food is taken, there is scarce any motion. The animal is incapable of digging itself a hole, and either protects itself by a very thin and imperfect covering from the air, or perishes by the first cold weather.

The external calcareous operculum of the snail appears upon examination to be composed of the carbonate of lime. The secreting organ by which this substance is prepared is the collar, (collièr or fraise) the same to which is owing the calcareous covering of the whole animal. That the carbonate of lime is contained in the vessels of this organ is shewn by the fact that if it be touched by a foreign substance, there exudes immediately at the point of contact, this chalky liquid mixed with slime, and if the whole organ be cut off and immersed in an acid, an effervescence immediately takes place.

The final cause of torpidity in the snail, is doubtless the same as in all other torpid animals, to enable them to survive that portion of the year, in which from the degree of cold, the state of vegetation, &c. they would be cut off from their ordinary pursuits and sustenance, and of course could not continue to exist, were it not for some such provision. The particular time at which this state of torpidity commences does not however appear to be wholly dependent upon the access of cold weather, although the temperature of the air is one of the principal exciting causes. By keeping a number of these animals during the winter at a pretty high temperature, M. Gaspard succeeded in preventing a part of them from entering into the lethargic state at all, and by continuing the experiment upon the same individuals, one was made to pass without it through the third winter. But, notwithstanding this high temperature, many of the subjects of these experiments went into their state of torpidity at the same time, and with exactly the same precautions as if they had been exposed to the severity of the external air, and became lethargic where the thermometer was at 76°,

just as they would have done where it was at 40°. It appeared also that by exposing them to a degree of artificial or natural cold almost down to the freezing point, at any other season, but that at which they usually became torpid, this state could not generally be produced, and that even by confining them during summer in grottos and cellars where the temperature was steadily as low as 50°, they did not shut themselves up as in autumn; a few only, at most, protecting themselves from the cold air by a calcareo-membranous barrier, without burying themselves at all inthe earth. It may be concluded then, that in all probability a concurrence of other circumstances besides the accession of cold is necessary to the production of this effect; what these are cannot exactly perhaps be pointed out, but from the wasting away and final death of those animals which had been prevented from entering at all into the torpid state for one, two or three winters, it seems probable that this annual seclusion is constitutional and in some way, necessary to their health and economy.

During the whole period of hybernation, the animal powers of the snail are entirely suspended, with the exception of a slight muscular irritability, which may be detected upon touching the collar after the operculum has been removed. As no food is taken, digestion must necessarily cease. Upon dissection the stomach is found empty, and the intestinal canal filled with a thick brown liquid, but destitute of fæces. The circulation also appears to be suspended. The heart, immediately after hybernation begins, may be seen to beat distinctly, but with less force than in summer; as the cold advances this action ceases entirely; a gentle heat restores it, but on the re-application of cold it again ceases.

It has been supposed that snails, in their torpid state, breathe by means of an aperture existing in their shell, or that the air obtains admission through the pores of the operculum. But M. Gaspard preserved snails for three months under water at the temperature of 40° to 45°, and found them alive in the spring and ready to enter upon the functions of life with their usual vigour. The same was the case with those which were kept immersed through the whole winter in mercury or in oil; those which were buried under fat or surrounded with it; and those also from whom the air contained within the operculum had been taken and collected under water; the air collected in this manner retained its properties sufficiently to support combustion, and of course could not have been respired. It follows then that

these animals are capable of passing at least six months in the year without respiration.

In their animal heat and the degree of power which they possess, of resisting the influence of external heat or cold, snails do not differ essentially from other animals with cold blood. Their temperature is seldom above that of the medium in which they reside, and they are frozen, at a few degrees below the freezing point, nearly as soon as any other albuminous or gelatinous substance. When protected, however, by their operculum, and slightly buried in the earth, they resist the utmost extremity of the winter. But this power of resistance, in the opinion of M. Gaspard, is owing entirely to the advantage they take of the laws regulating the transmission of caloric, in constructing their barriers against the cold, and not to their vital power of resistance. During their torpid state if exposed to a cold of 15° they freeze; upon thawing are reanimated, but afterwards waste away and die; at 12° and at 10° death is complete and irrecoverable. But although this is the fact when they are made the subjects of experiment, yet many do really survive exposure to much lower degrees of cold in severe winters, and in their natural residences.

Exposed to a temperature of 98° snails are disturbed and issue from their shells with demonstrations of considerable uneasiness. If the heat be increased they give signs of great suffering, draw in their tentacula and retreat into their shells, which they soon leave again, and so alternately. At 120° they become incapable of all motion, their tentacula are hardened as if coagulated by the heat; they appear entirely dead: If the temperature be then slowly reduced, they exhibit some signs of reanimation, are gradually restored to life and do not appear to suffer essentially afterwards. After exposure to 124 and 126 degrees of heat, death is complete.

The functions of secretion, nutrition, and absorption, appear all of them to be suspended during the hybernation of the snail; so that during five, and in some climates, even nine months of the year, this animal lives without motion, heat, food, air or circulation; in a word, without the exercise of either the animal, organic or generative functions. In what then does its life consist, if life it can be called? It resembles that of a germ before fecundation, of a seed before it sprouts, of an egg before incubation, &c. It is rather a capacity for life, than life itself; a capacity which is called into actual exercise by the mild temperature of spring.

The manner in which the animal extricates itself from its confinement has nothing peculiar. It simply with its muscular foot, breaks through the different successive barriers till it arrives at the external air which it respires, and immediately moves about in quest of food. The warmth of the returning spring has undoubtedly much influence in rousing it from the state of torpidity, but still it is not the only circumstance which contributes to this end. Snails which are exposed to a temperature of 70° 80° or 100°, whether it be in November, January or April, will not revive, unless the heat be accompanied by moisture; whilst if the same animals, in either of these months, be placed under water, or exposed to rain, at the temperature of 56°, they revive and come out of their shells. The influence of moisture is so great, that if one animal be exposed to a fall of rain, and another very near it, be protected by some covering, the first will revive immediately, but the second not for a long time. And in a room where a large number of snails were kept, it was sufficient, to open the windows during a shower, a fog, or a south wind, to bring out those of them which were exposed; whilst those protected in any way from the influence of these circumstances, remained unaffected.

Considering a certain degree of heat and moisture and the season itself as combined together in exciting these animals to revive from their hybernation, M. Gaspard made some experiments to ascertain by what means they could be prevented for the longest time from this revival. By putting them away in a cellar or in the most remote part of a cave, he succeeded in retarding it from 15 to 25 days; but when they were confined in bottles perfectly dry and well stopped, covered with fat, or immersed in oil or mercury, so as to exclude them entirely from the access of moisture, they emerged at the usual time, or even a little sooner. What was a little surprising, those which were placed in a dry heat of 82° continued, some till June, some till July, one till the 10th of August and one till the 1st of October, before leaving their shell; so that at this temperature, if great dryness be preserved, snails may be kept for some months or even a whole year in their torpid state. Not that they continue the whole of this time without performing any of the functions of life; M. Gaspard is of opinion that during the warmer months, a low degree of action is going on in the system.

During the dry parts of the summer months snails frequently enter into a partial state of torpidity to preserve themselves from the bad effects of the dryness of the air.

They attach themselves to some neighbouring substances, a stone, tree, &c., by means of a circular silky band, surrounding the opening in its shell, which completely excludes the external air with the exception of a small opening just opposite the orifice of the trachea. In this state they remain till a fall of rain, when they immediately set themselves free; the same effect is produced if they be only sprinkled with water; and if the soil be not very dry, as in a meadow, or if there be heavy dews at night, they release themselves at night and keep confined only during the day. But during this temporary seclusion the functions of life are not suspended as in winter. It is proved that respiration, circulation and nutrition, all proceed nearly as in the natural state.

The blood of the snail is worthy of some little notice. It is contained not only in the proper circulating vessels, but when the animal is moving, it is also poured out into the cavity containing the digestive and genital organs which actually are bathed in this fluid. When the animal is at rest, this phenomenon is no longer to be observed. The blood is abundant in snails, tolerably thick, but not viscous, of a nauseous odour, and a taste slightly saline. It is of a fine blue colour, which is not altered by difference of food, by asphyxia, or by hybernation. It is heavier than water. It is not coagulable like the blood of vertebral animals, upon exposure, but it separates into two distinct liquids, one blue, which rises to the top, the other colourless or opaque which sinks to the bottom of the vessel. It is unaffected by the muriate of barytes or by alcohol at 96°; is simply discoloured by potass, vinegar and the weaker acids; the acetate of lead, the nitrates of silver and mercury throw down thick and abundant precipitates; whilst boiling water and the nitric and sulphuric acids coagulate it like albumen.

It was the opinion of Swammerdam, that each of the two projecting horns of the snail had at its extremity a proper eye, composed of an aqueous crystalline and a virtreous humour, with an optic nerve, &c., and in this opinion he has been followed by many distinguished naturalists. M. Gaspard, on the contrary, is convinced that the snail is completely blind, wholly insensible to sight, and moving equally well in the night, as in the day. He has found that it does not perceive obstacles placed in its way, nor take measures to avoid them until it has actually touched them with its horns; and that those which have been deprived of these organs find their way as readily and safely as those which

retain them. He concludes that these horns or tentacula are only the organs of a very delicate sense of touch, endowed with an exquisite sensibility to heat, dryness and moisture, to the slightest jar, or to the least agitation of the air; that they are of the same use to the snail, that a cane is to the blind man, in feeling his way.

These animals appear also to be deaf as well as blind. They are found totally insensible to the most acute and hidden sounds, giving no demonstration that they perceive them. But they are very sensible to concussions communicated through the medium of the ground, whether accompanied by sound or not; in the same way that deaf persons are sometimes able to distinguish sounds by means of the vibrations communicated to the whole body.

It has been supposed that snails are possessed of the sense of smell; and that they are directed towards the food which is grateful to them, by means of this sense. M. Gaspard has been able to detect no proof of its existence, thinks that it does not exist, and that the sense of tasting and feeling are the only ones which they possess.

M. Gaspard has repeated the experiments of Spallanzani instituted to determine the power of regeneration possessed by these animals. In some instances both the head and tentacula were removed; much blood was lost and the animals retreated immediately into their shell where they remained shut up for a month. At the end of this period, they came out again, presenting a well cicatrized wound, moving about as usual, and with as much accuracy and appearing as sensible to the least touch and to a simple concussion of the earth, as before. At the end of about two months and a half, one or two fleshy tubercles, transparent and truly regenerated, appeared upon the cicatrix, and gradually approached to the form and functions of the tentacula, but without the black spot in the extremity usually supposed to be the eye. Finally, however, all these animals died in about six months, having gradually pined and wasted away, and without any attempt at going through the preparations necessary to their hybernation.

A snail which had suffered the loss of merely its two tentacula, exhibited at the end of two months a tender fleshy tubercle at each of the wounds, which however, had increased in size but little when the animal went into winter quarters. During its hybernation, no progress was made, but during the next season the new organs had acquired nearly the length of the old, but were slender, fusiform, transparent

and without the black point at the extremity. The accidental destruction of this animal prevented the observation of the further development of its regenerated organs.

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Art. LXX.—*Account of some experiments, made for the purpose of determining the effect of great compression, in a fluid medium, on different substances.* By D. Treadwell.

These experiments were made by placing the subjects of them in the cylinder of an Hydrostatic Press. The amount of the force applied, was pretty accurately determined. They were as follows. 1. A piece of dry birch, weighing 47 grs. was subjected to the pressure of water, on all sides, equal to 2,000 pounds on each inch of its superfices. It was found after one minute to have gained 40 grs. in weight and its specific gravity to exceed considerably that of water. This pressure is about equal to that of the ocean at the depth of 4,500 feet. 2. A piece of the heart of maple, perfectly green, containing about 25 cubic inches and weighing 13 oz. having been previously soaked for 30 hours, was subjected to the pressure of 600 pounds per inch for 2 minutes. It gained in weight 1¼ oz. This weight of water must have a volume equal to ⅛th of the volume of the wood. In the next experiment several different substances were placed into the cylinder together. These were a mackerel, weighing 4416 grs.; a piece of the tooth of hippopotamus weighing 460 grs.; a lemon weighing 1320 grs.; an egg, weighing 798 grs.; and 3 pieces of cork weighing 147 grs. The pressure applied was about 4,000 pounds per inch, equal to the pressure of a column of water 9,000 feet high, and it was continued about 5 minutes, when the different substances were taken out and weighed. The mackerel was found to have lost 40 grains; the piece of sea horse tooth had gained 3 grs., the lemon 16 grs. and the corks 40 grs. The egg was broken, somewhat contrary to expectation, as I thought it not unlikely that the water would have forced its way through the shell fast enough to have equalized the pressure. It is somewhat difficult to

account satisfactorily, for the diminution of the weight of the mackerel. It was not very considerable, compared with the whole weight, and might have been owing to some accidental circumstance.

I attempted to ascertain with another apparatus whether solid animal matter is more compressible than water. Some small pieces of muscular flesh and of fish were fixed by small brass pins to globules of tallow, so that the whole had a specific gravity exactly equal to that of water. They were then subjected to a pressure in a glass tube, filled with water, by means of a piston. The pressure was equal to about 200 pounds per inch; but they were condensed so equally with the surrounding water that they did not sensibly rise or fall in the tube.

There is a subject intimately connected with the preceding experiments, which does not appear to have excited the notice of the curious, to the extent which its extraordinary character merits. This is, the great pressure which fishes and the cetaceous animals sustain in their ordinary way of life. A pressure always changing in degree; as when the animal approaches near the surface of the water, it is almost wholly removed, and again, on its suddenly descending to the bottom, enormously increased*. This, taken in connexion with the effect produced on man, and probably all land animals, by the slight variation of the pressure which he usually sustains, as on ascending mountains or descending in a diving bell, renders still more striking the power which enables fishes to support the weight of the ocean†.

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* There are some species of fishes which cannot pass from shallow to deep situations very rapidly, owing to the structure of their air bag or sound. Biot in a memoir "*Sur la nature de l'air contenu dans la vessie natatoire des poissons*," published in the Memoires d'Arcueil has spoken, incidentally, of the effect which the expansion of the air in this organ necessarily has on fishes drawn suddenly from great depths. In those species in which the air bag is a close sack, as in the cod and haddock, the enormous increase in volume of the air, from the diminished pressure, as the fish is made to approach the surface of the water, often produces a retroversion of the stomach protruding it from the mouth. This effect is not uncommon.

† Capt. Scoresby in his account of the Greenland whale fishery has mentioned this subject at some length. He supposes that the state of exhaustion often exhibited by the whale on rising from its descent after having been struck by the harpoon, is as much the effect of the great pressure of the water, as of its efforts to free itself from its enemies.

**Art. LXXI.**—*Sketches of the Progress of Inventions, connected with Navigable Canals. Compiled from various sources.* [T.]

(Continued from p. 491.)

Since the publication of our last number, J. L. Sullivan Esq. has favoured us with a description of a new mode of building locks, invented by himself. The following is Mr Sullivan's communication.

*Explanation of the Principles of the Composite Lock.*

The object of the Composite Lock, is to use wood, as the cheapest material, and yet so that it shall be *durable*. This is effected by excluding from the substance of the structure, the *causes* of decay, *air* and *water*. The means of doing it, are found in the following mechanical and chemical principles, using as materials thin boards, sheathing-paper, pitch and lime.

The manner of building affords the greatest strength, because the fibres of the wood cross each other in alternate layers, transverse and lengthwise; trenailed very firmly, as they are successively put together; and with intermediate tarred paper: each succeeding surface being payed with pitch, after the seams are caulked. This separation of every piece of wood, from every other, prevents fermentation and rot between them; and if the work is well done, the structure must be impervious to water and air. Then as carbonaceous substances are of an imperishable nature, this wooden fabric, by being penetrated and filled with tar, must by its efficacy remain sound, as long as this substance retains that property.

The use of a small proportion of lime, among the pitch, is to form a *cement*, and neutralize any acid that may be in the wood.

This method has some analogy to the well known use of the pyro-ligneous acid, in preserving provisions, now beginning to be applied to the timber in ships. Its efficacy is attributable to the anticeptic properties of the components of smoke (vinegar and carbon.) Smoke differs from tar principally in being *volatile*, instead of being concentrated. But pitch, which is a more concentrated tar, is better for this

purpose; because, besides penetrating the pores of the wood, it forms a defence of its surface. One of the late improvements in the British navy (by Mr Seppings) among others, is to inject a ship's frame, or to fill the pores of the wood with tar.

The manner of building a *composite lock chamber* is simply this: the pit being dug, rough walls will of course be necessary to sustain the ground: these will also sustain the lock laterally, and its upper end.

After bolting a cap-piece on the walls, having an under groove overhanging the space a few inches, and after flooring the space between the walls with a mass of small stones for the bottom of the chamber to rest on, the work is begun by lining the space, first with thin oak boards (as bending more easily) which reach from the under groove of the cap on one side, down the wall, across the bottom, and up the opposite wall to the groove on the other side, nailed to each cap. The seams being chinced with oakum and the whole surface payed, it is then covered with tarred paper. It is now ready to receive the first *lengthwise* layer of pine, to be trenailed or nailed through the paper to the first layer. This second course is next to be caulked and payed and papered, to receive the *second transverse* layer of oak, which is covered and completed in like manner; and the fourth course, or second lengthwise (if the last) is finished by caulking and graving. The *trenails* of the successive lamina all reach to the first layer. They are made by machinery and compressed that they may expand and cohere more firmly after being driven.

But if the lock is of uncommon depth, which this method of building permits, one or two courses more may be expedient. Two locks of this kind may be made to lift as many feet perpendicularly, as *three* locks on the old and usual plan: thus saving one third of the locks of a canal.

The outside surface only is exposed to the air; but as it is in contact with stone which keeps it cool, it will remain sound. The inside surface will be protected sufficiently by a renewal of its coat of pitch from time to time. The bottom being always under water will remain sound. The gate-posts may be either of wood, stone, or cast iron. Instead of culverts, horizontal pivot gates are used (as on Middlesex canal;) placed above the upper pair of lock gates, which let the filling water descend into the lock chamber, through the upper floor; the lower floor being protected from wearing by means of timbers, plank or stone.

The saving in the first cost of this kind of lock, compared with cemented walls, is such, that were the difference put at *interest* for the period of its duration, it would amount to many times more than the expense of replacing the chamber eventually. It is therefore true economy. This manner of building is also well adapted to our country and climate; as the material abounds, and the frost sometimes heaves the walls of locks and destroys the cohesion of their cement: In England and France the winters are too mild for this effect.

Thus great durability is given to a wooden structure, and lockage in river works made more practicable, and less costly. In this way may be also constructed the *aqueducts* of a canal. J. L. SULLIVAN.

Mr Sullivan has also furnished a description of a machine, invented by Mr Dearborn, of this city, as a substitute for the lock. This machine, although it bears a strong resemblance to some of the inventions described in our last, under the name of balance locks, is yet, we should think, more practicable than any of them. A single vessel, which Mr Dearborn calls a *transit*, is suspended by chains, running over pullies, and counterbalanced by weights. In this the canal boat is moved vertically, from one level to the other, and such provisions are made, that no change of the levels from floods or drought can derange the operations.

Having noticed the principal inventions for uniting different levels or sections of canals, we shall proceed with an account of some of the striking improvements in the architecture of these works. Amongst these, none are more imposing than the tunnels and aqueducts. The first tunnel constructed for the purpose of navigation, was on the Languedoc canal. This was considered the wonder of its time. It was cut through the ridge of Malpas, near the town of Beziers; its length is 720 feet, and for the most part of the way it is lined with stone. The expense of this work has been stated at 13,000,000 livres. An enormous sum, considering the value of money, and the resources of France at that period, (1670).

The tunnels connected with Bridgewater's canal were the first works of the kind undertaken in England, and they continue unrivalled in extent and importance. These tunnels are said to be, in all, more than 18 miles in length; many of them hewn out of the solid rock, and sufficiently large for the passage of boats 4½ feet wide. From a branch which

passes under Manchester, coals are taken up, for the supply of that town, by simple machinery, constructed by Brindley.*

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* James Brindley, the engineer under whose direction Bridgewater canal was constructed, and whose name is so intimately connected with canal improvements, possessed so rare a genius, and was of so singular a character, that we cannot forbear giving some account of him. He was born in Derbyshire, in 1716, and his father, having wasted his small property in field sports, young Brindley was obliged to labour, almost from his infancy. At the age of seventeen, he bound himself apprentice to Mr Bennett, a millwright, near Macclesfield. Here, the superiority of his genius unfolded itself, and long before the expiration of his apprenticeship, the millers placed more confidence in his opinions than in those of his master, and such was his devotion to his business, that for the purpose of obtaining correct information about some parts of a paper-mill, he took pains to visit a mill, at the distance of fifty miles, between Saturday evening and Monday morning; this being the only time he could spare from his work. After the expiration of his apprenticeship, he was employed on various works, and his reputation was constantly increasing in his little circle, until he attained the age of forty. It was at this period of his life, that the Duke of Bridgewater required his assistance for his projected canal. Here his genius found its proper field, in planning and executing that great work. He however accomplished all the parts of his undertaking in a manner, not only satisfactory to the Duke of Bridgewater, but with such display of talent, that succeeding engineers have constantly referred to his works as models for imitation. The strength of his genius is made the more apparent when it is considered, that his profession, more than most others, requires mathematical learning, and that he was so wholly illiterate, that it is yet in some degree disputed, whether he could even read or write. When any great effort of his mind was required, it was his custom to retire to bed, where he remained until his task of invention was accomplished, which sometimes lasted two or three days; when he would get up and put his design at once into execution. He kept his attention so unrelaxingly fixed to the subject of his profession, that having been prevailed upon once, when in London, to go to a play, he declared afterwards, that he would never repeat the experiment, as the spectacle produced such a distraction of his thoughts, as to unfit his mind for its proper actions. An answer of his, to a committee of the House of Commons, shows strongly his singleness of purpose. Having, at an examination of some points relating to canals, spoken lightly of the use of

Tunnelling can only be accomplished by tedious digging and blasting; it necessarily goes on slowly, as no more room can be obtained for the labourers, than they burrow for themselves.

Aqueducts for continuing canals over vallies and rivers, are constructed on principles similar to those which guide the construction of bridges. They differ little from the common bridge, except in having, in the place of a road, a water-tight channel, through which the canal water and boats pass. Aqueducts, equally with bridges, may be made an ornament to the country, by a proper architectural arrangement. It is not our purpose, however, to consider them in the light of ornamental structures, but simply as works for continuing the levels of canals. In this view, the material of which they are constructed is of great importance. In Europe, until within a few years, stone was the only substance considered proper for these works; and the ancient aqueducts, for supplying cities with water, attest forcibly to the durability of this material. Wood, which has been so freely used in all works in this country, has up to the present time been the principal article in our aqueducts. But its certain and speedy decay has shown how utterly unfit it is for this purpose. The aqueducts on the Middlesex canal, although built but about twenty years since, have not only required large repairs, but we believe, one of the most expensive of them has required to be rebuilt.

We are happy to see that a sounder judgment or richer means, has directed the execution of these works on the great western canal, and we may instance the aqueduct which conveys that canal over the Genesee river, as worthy of imitation in other rising works. This aqueduct, as appears from an account by Mr Bates, engineer for the section of the canal in which it is situated; is about 800 feet long, crossing the river with 11 arches, most of which are of 50 feet chord. The piers are of no very magnificent height, but are substantially built. The whole fabric is of hewn stone and sufficiently massive to give it durability. It was built with the rapidity which characterizes our countrymen in all their undertakings: it having been completed in little more than one year from its commencement.

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rivers for navigation, he was asked, what he thought rivers were made for? after a moment's hesitation he replied; "to feed canals with." Mr Brindley died at the age of fifty-six years

A very important improvement was made, in England, a few years since, in constructing aqueducts. We shall give the history of this invention from the excellent article, *Navigation Inland*, in the Edinburgh Encyclopædia.

"But about the year 1795, Thomas Telford having been entrusted with the management of the Shrewsbury and Ellesmere Canals, had his attention drawn to the construction of some large aqueducts, and having observed, in several instances, the masonry of aqueducts where puddle was employed, to be cracked, and very subject to leakage, and some parts not unfrequently obliged to be taken down and rebuilt, or tied across by strong iron bars; these circumstances led him to consider of introducing cast-iron work. This he did, in the first instance, upon the Ellesmere Canal at Chirk, where the aqueduct was 600 feet long, and 65 feet high above the river; here he rejected puddle, built the spandrels over the arches with longitudinal walls only; across these walls cast-iron flaunched plates were laid, as a bottom to the canal, and also on purpose to bind the walls horizontally; these were well jointed, screwed, and caulked; the sides of the water channel were built with stone facings, and brick hearting laid in water lime mortar. By this mode the quantity of masonry was much reduced, yet the whole remains water-tight and substantial, after being worked 20 years.

"About the same time, and on the same canal, it was found necessary to cross the river Dee, at the bottom of the celebrated valley of Llangollen, at Pontcysylte, at the height of 126 feet 8 inches, above the surface of the river, and for 1000 feet in length, it was cheaper to aqueduct than embank. Here Mr Telford introduced a still more decided deviation from the usual form, by building upright piers only, and, instead of masonry arches, putting cast-iron ribs between them, constructing the canal part by cast-iron flaunched plates for the sides as well as the bottom, and in order to preserve as much as possible of water-way, projecting the towing path over the water in the canal. The canal part is 12 feet in width, which admits boats of 7 feet beam, and a towing-path. This aqueduct has now been worked about 15 years, and has answered the purpose for which it was designed; where the embankment commences, the height is 75 feet, but gravelly material being very convenient, rendered embanking cheaper than carrying the masonry and iron-works any farther.

"In the three magnificent aqueducts recently constructed upon the Edinburgh and Glasgow Union Canal, the modes of the two last mentioned aqueducts are combined, that is to say, the masonry of the arches and spandrels are preserved, as in Chirk, and cast-iron plates for the bottom and sides, as in Pontcysylte. are introduced within the masonry; how far it was judicious to incur the expense of providing two modes of security in the same structure, appears rather questionable. In Pontcysylte the upper parts of the piers only are hollow, with one cross wall in each; in the Union Canal, the piers are brought up hollow with cross-walls from the foundation; this mode, with an equal quantity of masonry, embraces a greater extent of base, and having more external and internal surface, ensures better materials and workmanship."

An inquiry, preliminary to every other, regarding the practicability of forming a navigable canal through any tract of country, is, whether a sufficient quantity of water can be obtained to supply the elevated sections.

The supply must be not only enough for the locks, but for the waste by evaporation, leaks, and percolation through the bottom and walls. These last are however, so inconstant, varying from the workmanship of the canal, the nature of the soil, the climate, and other causes, that no accurate estimate can be made of their amount, which could serve as a rule of general application. The accession of water to the canal, from rains, although it may in quantity equal the evaporation and leakage, must not be relied upon as forming a compensation to them; as in some seasons, a canal might suffer severely from a long continued drought. In considering this subject in connexion with the practicability of supplying canals with water by the steam engine, we may take as an example, the water required to supply the Middlesex Canal. The line of this canal which runs from Concord to Charlestown, a distance of 22 miles, is supplied by the water which flows through an aperture of 6 feet by 1 foot. The head of water being 2½ feet above the middle of the aperture, the mean velocity of the stream issuing from this aperture is, consequently, 9 feet per second, nearly. This gives to the canal 3240 cubic feet or 2,015,000 pounds of water per minute. A good steam engine will raise 40,000,000 pounds one foot high, with every bushel of coals consumed; consequently to raise the above supply of water 20 feet high, by the steam engine, would require an expenditure of fuel, equal to 1 bushel of coals per minute. Notwithstanding this, however, there may be situations where

the advantages of a canal will prevail against even this expense, and in fact, in a few instances, in England, the summit levels, are wholly or in part, supplied with water raised from neighbouring fountains by the steam engine.

We have not room to go into the subject of the great change, so often attempted, in the mode of moving boats on canals; we allude to the attempts to apply the steam engine to this purpose. It will be recollected, that the first experiments, for propelling boats by the steam engine, were made on canals. These resulted in failure, and many different plans tested since have terminated in the same way. Indeed the difficulties of propelling canal boats by the steam engine must strike any one, who attends to all the circumstances connected with it, as great, if not insurmountable.

## Art. LXXII.—*Account of the Donation made by Count Rumford to the American Academy of Arts and Sciences, for the establishment of a biennial Premium.*

In the year 1796 Count Rumford, then residing in London, presented to the American Academy of Arts and Sciences, five thousand dollars, in 3 per cent stock, for the purpose of establishing a biennial premium to be awarded to the author of the most important discovery or most useful improvement on heat or light which should be made in any part of America. The following letter addressed to the President of the Academy, accompanied the donation, and contains an account of the views of the liberal donor, and of the terms upon which the premium was to be awarded.

*To the Hon. John Adams, President of the American Academy of Arts and Sciences.*

Sir,—Desirous of contributing efficaciously to the advancement of a branch of science, which has long employed my attention, and which appears to me to be of the highest importance to mankind; and wishing at the same time to leave a lasting testimony of my respect for the American Academy of Arts and Sciences, I take the liberty to request

that the Academy would do me the honour to accept of five thousand dollars, three per cent stock, in the funds of the United States of North America, which stock I have actually purchased, and which I beg leave to transfer to the Fellows of the Academy, to the end that the interest of the same may be by them, and by their successors, received from time to time, for ever, and the amount of the same applied and given, once every second year, as a premium to the author of the most important discovery, or useful improvement, which shall be made and published by printing, or in any way made known to the public, in any part of the continent of America, or in any of the American islands, during the preceding two years, on heat, or on light, the preference always being given to such discoveries as shall, in the opinion of the Academy, tend most to promote the good of mankind.

With regard to the formalities to be observed by the Academy in their decisions upon the comparative merits of those discoveries, which, in the opinion of the Academy, may entitle their authors to be considered as competitors for this biennial premium, the Academy will be pleased to adopt such regulations, as they in their wisdom may judge to be proper and necessary. But in regard to the form in which this premium is conferred, I take the liberty to request that it may always be given in two medals, struck in the same dye, the one of gold, and the other of silver, and of such dimensions, that both of them together may be just equal in intrinsic value, to the amount of the interest of the aforesaid five thousand dollars stock, during two years; that is to say, that they may together be of the value of three hundred dollars.

The Academy will be pleased to order such device or inscription to be engraved on the dye they shall cause to be prepared for striking these medals, as they may judge proper.

If during any term of two years, reckoning from the last adjudication, or from the last period for the adjudication of this premium by the Academy, no new discovery or improvement should be made, in any part of America, relative to either of the subjects in question, (heat, or light,) which in the opinion of the Academy, shall be of sufficient importance to deserve this premium; in that case, it is my desire that the premium may not be given, but that the value of it may be reserved, and being laid out in the purchase of additional stock in the American funds, may be employed to augment the capital of this premium; and that the interest

of the sums by which the capital may from time to time be so augmented, may regularly be given in money, with the two medals, and as an addition to the original premium, at each succeeding adjudication of it. And it is further my particular request, that those additions to the value of the premium arising from its occasional non-adjudications may be suffered to increase without limitation.

With the highest respect for the American Academy of Arts and Sciences, and the most earnest wishes for their success in their labours for the good of mankind,

I have the honour to be, with much esteem and regard,

Sir,

Your most obedient,

humble servant,

RUMFORD.

*London, July 12th*, 1796.

Upon the receipt of the donation, the thanks of the Society were presented to Count Rumford in the following terms:

Voted, That the thanks of the Academy be presented to Count Rumford, for this his very generous donation, and that they experience the highest satisfaction in receiving this additional and very liberal aid for the encouragement and extension of those interesting branches of science, which he has specified as the objects of his gratuity, and which *he* has so successfully cultivated: That they entertain a high sense of the sentiments and views, so becoming a philosopher, which have prompted him to this distinguished act of liberality; and in the execution of the grateful office, which they have undertaken, of awarding and distributing the premium which Count Rumford has thus appropriated, they will sacredly comply with the conditions of the donation; indulging the hope, that he will meet his reward, in learning that many in his native country are thereby excited to emulate his labours, and to promote the accomplishment of his beneficent wishes for the advancement of science, and the augmentation of human happiness.

At a meeting held in May 1801, the Society voted, that they would, at their meeting in May of the next year and afterwards, biennially at their May meeting, decide upon the discovery or improvement which appeared to deserve the Rumford premium. The subject we believe has frequently been brought before the society and they have been ready at the appointed time to confer the premium upon any individual whose claims were sufficient to authorize it.

No discovery, however, or improvement has yet been made which has been deemed worthy this honor, and the fund has of course been accumulating, according to the terms of the donation, ever since it has been in the hands of the Society.

At the present time the fund amounts to $7361, 19, in 6 per cent, and $7050 in 7 per cent stocks. The premium awarded would therefore be the interest of these sums for two years; three hundred dollars in the form of a silver and a gold medal and the residue in money. This we believe is one of the largest premiums offered by any society or institution for discoveries in science or improvements in the arts, and is well worthy the attention of the scientific and ingenious men of our country.

The next meeting of the Society will be held on Tuesday the 25th of May next, at their room in the Boston Atheneum. At this meeting the Society will be ready to decide upon any claims which may be offered for the premium in question; it being the regular biennial period at which, by their vote of 1801, this subject comes before them.

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## General Intelligence.

*Improvement in Clocks.*—The public papers, sometime since, contained information of an improvement in timekeepers, invented by Mr Dyar of this city. We hope hereafter, to furnish our readers with a more particular account of this invention than is contained in the following brief notice.

The most important feature in this improvement, consists in the application of the *spiral teeth* to the wheel work of clocks, and in this the pinion is reduced to a single tooth. By this happy idea, Mr Dyar has greatly reduced the wheel work necessary to a clock, and the friction is diminished in a still greater degree; as all who are acquainted with the spiral gearing are aware, that the point of contact, between two wheels with spiral teeth, always coincides with the line of centres. Mr Dyar has also contrived a very ingenious method of suspending the pendulum, in place of the spring, or knife edge suspension. This method is to hang the mass constituting the pendulum to a plane, the under surface of which rolls at every oscillation upon a fixed con-

vex body. He proposes to give such a curve to the convex surface, that the pendulum in vibrating shall be accelerated at every moment of its descent by a force proportional to the arch between it, and the lowest point; this condition being required to render the vibrations isochronal. Mr Dyar has not yet demonstrated the curve necessary to obtain this result; but from the constant variation of the centre of oscillation, in a pendulum suspended in the above method, the cycloid is not the curve required. He is aware that his suspension cannot be executed with such accuracy as to render the vibrations perfectly isochronal; but he may undoubtedly obtain a near approximation to a curve which would render them so.

### *Elements of the Orbit of the Comet of* 1823.

(Communicated by Warren Colburn.)

*Perihelion distance*, 0.2490054—(the sun's mean distance from the earth being 1.)

*Logarithm* of Perihelion dist. 9.3962088.

*Time of passing Perihelion*, 1823, Dec. 8d. 14h. 06′ 52″ mean time at Boston.

| | |
|---|---|
| *Inclination* of the orbit to the ecliptic, | 75° 06′ 49″ |
| Longitude of the *ascending node*, | 302° 37′ 41″ |
| *Place of the Perihelion*, (on the orbit) | 271° 39′ 11″ |

Motion retrograde.

These elements were computed from observations made at Waltham. The instrument used was a sextant. It is impossible under the most favourable circumstances, that observations with a sextant should be so accurate as those made in an observatory. In the present instance the comet was dim, and the body ill defined; and, on account of bad weather, but few observations could be obtained.

It is believed that the above elements are as accurate as the observations will admit. They agree very well with the observations published in the last number of the Boston Journal, but not quite so well as the following, which were found by combining these latter observations with those made at Waltham.

*Perihelion distance* 0.2429487.

*Time of passing the Perihelion*, 1823, Dec. 8d. 17h. 23′ 8″ mean time at Boston.

| | |
|---|---|
| *Inclination* of the orbit to the ecliptic, | 77° 05′ 13″ |
| Longitude of the *ascending node*, | 303° 23′ 52″ |
| Place of Perihelion (on the orbit) | 272° 55′ 9″ |

Motion retrograde.

The comet when it first appeared, which was in the latter part of December, was receding from the sun. Its distance from the sun at that time was about two thirds of the distance of the sun from the earth, and its distance from the earth was a little more than three fourths of the distance of the sun. The earth at that time was approaching the point of its orbit over which the comet was to pass, and when the comet passed the earth's orbit, the heliocentric longitude of the earth and comet was nearly the same; so that the comet passed very nearly over the earth. This happened between the 20th and the 23d of January. At that time it was nearest to the earth, being distant about 42 millions of miles. Afterward it receded very fast and disappeared early in February.

The elements of no comet yet observed agree with these. It must therefore be considered as a new comet.

The following are the elements of this comet as determined by Dr Brinkley, of Trinity College, Dublin.

Perihelion distance . . . . . . 0.264

Passage of the Perihelion, Dec. 8d. 13h. 7′ 44″ M. T. at Dublin.

| | |
|---|---|
| Inclination, . . . . . . | 75° 47′ 30″ |
| Longitude of the ascending node, . . | 302° 51′ 40″ |
| Longitude of Perihelion, . . . | 269° 30′ 30″ |

Motion retrograde.

The agreement of these elements, with those obtained by Mr Colburn, is much more exact than could be expected, considering the different means of observation possessed by the two observers. Indeed, *no perfectly accurate observations can be made* with the instruments now in use in N. England.

*Effects of the Chloride of Lime as a Disinfector.*—MM. Orfila, Leseure, Gerdy, and Hennelie, having to examine the body of an individual who was supposed to have been poisoned, and who had been dead for nearly a month, found the smell so insupportable that they were induced to try the application of the chloride of lime, as recommended by M. Labarraque. A solution of this substance was frequently sprinkled over the body, and produced quite a wonderful effect, for scarcely had they made a few aspersions when the unpleasant odour was instantly destroyed, and the operation could be proceeded in with comparative comfort. [*Jour. Roy. Instit.*]

*Preservation of Green-house Plants.*—It has been ascertained by Mrs Tredgold, that plants may be completely protected from the depredations of insects by washing them

with a solution of bitter aloes, and the use of this wash does not appear to affect the health of the plants in the slightest degree. And wherever the solution has been used, insects have not been observed to attack the plants again. As there is much difficulty in preserving a small collection by the usual methods, this notice of a simple remedy may be very useful. [*Philos. Mag.*]

*Roman Cement.*—According to an analysis lately made by M. Berthier, the component parts of Parker's cement are

| | | |
|---|---|---|
| Carbonate of lime | | 657 |
| ——— | magnesia | 005 |
| ——— | iron | 070 |
| ——— | manganese | 019 |
| Clay silica | | 180 |
| —— alumina | | 066 |
| —— Water | | 013 |
| | | 1.000 |

M. Berthier is of opinion, that with one part of common clay and two parts and a half of chalk, a very good hydraulic lime may be made, which will set as speedily as Parker's cement. He concludes from many experiments, that a limestone containing six per cent of clay affords a mortar, perceptibly hydraulic. Lime containing from 15 to 20 per cent is very hydraulic; and when from 25 to 30 it sets almost instantly, and may therefore be held to be, to all intents and purposes, real Roman cement. [*Ibid.*]

*Improved Process for preparing Hydraulic Cement.*—A patent has lately been granted in England, to James Frost, for an improved process of calcining and preparing calcareous and other substances for the purpose of forming cements. The process consists in calcining the substances in reverberatory furnaces or kilns, and excluding the atmospheric air when they have been sufficiently calcined by stopping and luting all the apertures until the furnace and its contents are cooled, or the hot calcined material is drawn through an aperture in the floor of the furnace into an iron or other cylinder with a corresponding aperture, but impervious to air or moisture on all other sides but that in contact with the floor of the furnace. In this cylinder the material is allowed to cool, while another portion is being calcined in the furnace.

Such mixtures of calcareous and other earths and oxyds as can be sufficiently calcined at a bright red heat, are placed in tight iron cylinders furnished with safety valves for the escape of the elastic fluids. Other cylinders are at-

tached to the ends of these to receive the calcined materials and defend them from the atmospheric air while cooling. The cylinders are furnished with doors capable of being rendered air tight.

Chalk or carbonate of lime prepared by this method at a heat not exceeding that at which cast iron softens, becomes hydraulic lime, and formed into mortar, sets and hardens under water. [*Rep. Arts.*]

*Improved Method of Manufacturing White Lead.*—A patent has been granted to Mr Saddler for an improved process of manufacturing carbonate of lead. A solution of sub-acetate of lead, (liquor plumbi subacetatis Lond. Phar.) is placed in a cask or other vessel, either closed or open, and carbonic acid is introduced in the state of gas or in solution. The ingredients are agitated to favour the combination of the carbonic acid with the oxyd of lead which is contained in the solution of the sub-acetate and a precipitate of carbonate of lead is formed. The operation is continued as long as any absorption of carbonic acid takes place. The precipitate is separated, washed and dried in the usual manner. [*Ibid.*]

*Discovery relating to Sheathing Copper.*—At a meeting of the Royal Society, January 22, 1824, a paper was read "on a mode of preventing the corrosion of copper-sheathing, by sea-water, in ships of war and other ships." By Sir Humphry Davy, Bart. P. R. S.

The attention of the President having been drawn to this subject by the Commissioners of the Navy Board, he instituted a series of experiments upon it, and has discovered a simple and effectual mode of remedying the evil. Copper, when immersed in sea-water, however pure and malleable it may be, becomes covered with a coat of a green submuriate, a sort of rust, which when washed off, is succeeded by a similar one, and the process continues until the metal is completely destroyed.

It was evident that no alteration which could be effected in the copper would prevent its corrosion; the effect on different kinds of copper might be somewhat different, but the principal diversities must be owing to the variations in the saltness and temperature of the sea-water.

Sir Humphry was led to the discovery by the same principle which led him to that of the decomposition of the alkalies; namely, that chemical affinities might be balanced or destroyed, by changing the electrical states of the substances: it thence appeared that the corrosion of the cop-

per might be prevented by its being brought, by contact with another metal, into a negatively electric state; and he had accordingly found that by the contact of tin, forming part of an electrical circuit, of $\frac{1}{100}$th part of the surface of the copper, the desired effect was completely obtained. Other metals, positive in respect to copper, may be employed, as lead and zinc, but tin is preferable, on account of its capability of being brought into complete contact with the copper, by means of solder, and also because its submuriate is easily detached from the metal.

The experiments were made with ribbands of tin, and it was found that such a ribband, equal in substance to only $\frac{1}{360}$th part of the copper, effectually prevented the corrosion of the latter. They were so entirely satisfactory, that not the smallest doubt can be entertained of the perfect success of the method in practice; and the Lords Commissioners of the Admiralty have made arrangements for enabling the President to repeat them on the largest scale, on ships of war.

It is probable, Sir Humphry observes, that this method, besides preventing oxidation, will also prevent the adherence of vegetables and marine animals to the sheathing. [*Ann. Philos. March.*]

*M. De Laplace's Great Work.*—The fifth and last volume of the *Méchanique Céleste* has made its appearance, in which the question of the form of the earth is discussed in various new points of view: namely, 1st. The dynamic effect of the presence and distribution of the waters on the surface of the globe. 2dly. The compression to which the interior beds are subjected. 3dly. The change of size, which may result from the progressive cooling of the earth. The author has arrived at the following results: That the great mass of the earth is by no means homogeneous; that the beds situated at the greatest depth are the most dense; that those beds are disposed regularly round the centre of gravity of the globe, and that their form differs little from that of a curved surface generated by the revolution of an ellipsis; that the density of water is nearly five times less than the mean density of the earth; that the presence and distribution of the waters on the surface of the earth do not occasion any considerable alterations in the law of the diminution of the degrees, and in that of weight; that the theory of any considerable displacing of the poles at the surface of the earth is inadmissible; and that every geological system founded on such an hypothesis will not at all accord with

the existing knowledge of the causes which determine the form of the earth; that the temperature of the globe has not sensibly diminished since the days of Hipparchus (above 2000 years ago,) and that the actual loss of heat in that period has not produced a variation in the length of the day, of the two hundredth part of a centesimal second. [*Philos. Mag.*]

*Remarks of Sir H. Davy on the Condensation of the Gases.*—" One of the principal objects I had in view, in causing experiments to be made on the condensation of different gaseous bodies, by generating them under pressure, was the hope of obtaining vapours, which from the facility with which their elastic forces might be diminished or increased by small decrements or increments of temperature, would be applicable to the same purposes as steam. As soon as I had obtained muriatic acid in the liquid state, I had no doubt that all the other gases which have weaker affinities or greater densities, and which are absorbable to any extent by water, might be rendered fluid by similar means; and that the conjecture was well founded, has been proved by the experiments made with so much industry and ingenuity by Mr Faraday.

" The elasticity of vapours in contact with the liquids from which they are produced, under high pressures, by high temperatures, such as those of alcohol and water, is known to increase in a much higher ratio than the arithmetical one of temperature.

" In applying the condensed gases as mechanical agents, the small difference of temperature required to produce an elastic force equal to the pressure of many atmospheres, will render the risk of explosion extremely small; and if future experiments should realize the views here developed, the mere difference of temperature between sunshine and shade, and air and water, will be sufficient to produce results, which have hitherto been obtained only by a great expenditure of fuel.

" There can be little doubt that these general facts of the condensation of the gases will have many practical applications. They offer easy methods of impregnating liquids with carbonic acid and other gases, without the necessity of common mechanical pressure. They afford means of producing great diminutions of temperature, by the rapidity with which large quantities of liquids may be rendered aeriform; and as compression occasions similar effects to cold, in preventing the formation of elastic substance, there is

great reason to believe that it may be successfully employed for the preservation of animal and vegetable substances for the purposes of food."

*Purple Tint of Plate Glass affected by Light.*—It is well known that some pieces of plate glass acquire by degrees a purple tinge, and ultimately become of a pretty deep colour. This has been observed in the glass used for windows. Wishing to ascertain whether the sun's rays had any influence in producing this change, Mr Faraday selected three pieces of glass, which he judged capable of exhibiting this change; one of them was of a slight violet tint, the other two, purple or pinkish, but the tint scarcely perceptible, except by looking at the edges. They were then each broken into two pieces; three of them were wrapped up in paper and laid aside in a dark place, whilst the corresponding ones were exposed to air and sunshine. In about nine months they were examined. Those which had been secluded from light, had undergone no change; but the others had increased in colour considerably; the two paler ones the most. Thus it appears, that the sun's rays can exert chemical powers, even on such a compact body and permanent compound as glass.

*New Voyage projected by Captain Parry.*—It will be recollected that Captain Parry in his first voyage, discovered, after entering Lancaster Sound, an opening which he called Prince Regent's inlet; leaving that, which seemed to turn to the south-west, on his left hand, he proceeded in a northwesterly direction. This inlet promised well at the time, but the body of Lancaster Sound, not having been then explored, it was passed by. The admiralty, at the suggestion of Captain Parry, have resolved that this inlet shall also be examined, in order that no opening which promises success may be neglected; he is therefore to proceed thither in the ensuing summer, in the Hecla, and from the situation where Hearne discovered the sea, and the apparent direction of Prince Regent's inlet, he hopes to succeed in reaching Captain Franklin's Cape Turnagain through it. If the wished for discovery should not be made in this direction, at least so enterprising an officer, cannot be employed there without adding to our knowledge of regions, which, before modern improvements had taught us to master the elements, were inaccessible to the inhabitants of temperate climates. From his perseverance, however, we may look forward with some confidence to this third voyage accomplishing its ob-

ject, or making great approaches to its attainment. [*Tilloch's Magazine.*]

*American Medical Science.*—A late medical reviewer remarks, our transatlantic brethren have taken mortal offence at an expression which once fell from the Edinburgh reviewers, "Who ever goes to an American play, or who ever reads an American novel?" "What does the world yet owe to American physicians and surgeons?" The expression was a harsh one, savouring too much of nationality and might certainly have been spared; but having been used, it cannot be denied to have some real foundation. We cannot, at this moment, call to mind any one leading principle in pathology or physiology, any one acknowledged improvement in surgery, or any one remedy of general efficacy, proposed by an American practitioner.

*Petalite.*—Dr Bigsby has discovered Petalite on the north shore of lake Ontario, on the beach in front of York, the capital of Upper Canada. It is a rolled mass weighing about a ton. The mineral has been examined by Dr Troost; it occurs in crystaline masses, of a greyish white colour, with a tinge of green, and resembles some varieties of Tremolite, for which indeed it was first taken. [*See Jour. Acad. Nat. Sciences, No.* 8, *vol.* 3.]

*New Mineral.*—M. Levy, Esq. M. A. in the university of Paris, proposes to give the name Bucklandite (in honour of the distinguished Professor of Oxford) to a mineral found in the mine Neskiel, near Arendal, in Norway. It occurs crystalized; colour, brown, nearly black; opaque. The crystals easily scratch glass. Mr Levy could not find any cleavage parallel to the natural planes of the crystals, nor in any other direction. The substance has some resemblance to Pyroxene, but differs from it in crystallographical characters. It has also an analogy to amphibole, but amphibole cleaves very easily parallel to the lateral planes of the primitive.

The primitive form of the crystals appears to be an oblique rhombic prism, in which the two lateral planes are inclined to each other at an angle of 70° 40′; the base upon either of the lateral planes at an angle of 103° 56′ and in which the ratio of one side of the base to the lateral edge is nearly 100 to 97.

The crystals of Bucklandite are accompanied by large green opaque crystals of scapolite, lamellary black hornblende, and flesh coloured laminary carbonate of lime.

*Forsterite.*—Mr Levy has given this name to a very scarce and new mineral from Vesuvius, in honour of the late Mr Forster, the founder of one of the finest private collections, now the property of Mr Heuland. This substance occurs in small brilliant colourless and translucent crystals, accompanied by pleonast and olive-green pyroxene. It is sufficiently hard to scratch rock crystal.

## NEW LOCALITIES OF AMERICAN MINERALS.

*Zircon and Green Felspar of Beverly, (Mass.)*—In a former number of this Journal, page 390, we have noticed the discovery of green felspar at Beverly in this state. The specimens first found were met with in a stone wall; it was ascertained that the materials for the construction of the wall were taken from the common, or parade ground of Beverly, many years ago. Application was made to the proper authorities for permission to open the ground and make a thorough examination. The result of this undertaking has been highly satisfactory. The green felspar has been found in narrow veins traversing sienite, accompanied with crystals of zircon, and some other substances the nature of which has not as yet been satisfactorily determined.

The crystals of zircon have an amber brown colour, a resinous and oily lustre, with a fracture somewhat conchoidal and foliated. The cleavages in some of the crystals are tolerably distinct and indicate the octohedral primitive form. A few perfect octohedral crystals have been found.

The largest crystal in my possession, weighs 30 grains $\frac{5}{10}$ths, and its specific gravity is 4.06; it is a four sided prism terminated by a four sided pyramid; the terminal planes being set upon the lateral edges of the prism.

With the reflective goniometer I find the angle of inclination 134° 12′. The angles scratch rock crystal.

The hornblend and felspar which accompany these interesting substances very much resemble those of the zircon sienite of Von Buch, with a specimen of which in my collection I have carefully compared it. The structure of this rock and its geological connexions are highly interesting. The following is Von Buch's description of the Norway zircon sienite. It is strongly distinguished from every porphyry by the magnificent, coarse granular, and sometimes large granular felspar, partly of a pearl grey and partly of a red colour, which always strongly characterises the blocks by its high degree of lustre. It is equally distinct from granite, sienite or other similar granular stones by the preponder-

ance of the felspar. All the other ingredients seem to be sunk in this as a basis, and they often appear only occasionally; but hornblend is never wanting, and this hornblend is generally pretty characteristic and distinct; long black crystals, which possess a double foliated fracture by way of discrimination from mica—folia of mica also make their appearance but very rarely; and quartz shows itself in small grains, so as not to be altogether missed. It appears, in general, accidentally in the composition, and we search through whole hills without finding it again. Wherever the grains of the felspar meet, there remains almost always a small angular cavity into which crystals project. Among these, are the crystals of zircon, which give name to the rock. Epidote is associated with them in fine needles.

In the rock at Beverly, there is a great tendency of the component parts to assume regular crystalline forms, and a few perfect crystals of green felspar have been obtained.

*Phosphate of Lime.*—I have lately found a few pretty distinct crystals of phosphate of lime near the village of Stow, in this state. The crystals are disseminated in rolled masses of a coarse grained granite. They are portions of hexædral prisms, of a greenish white colour. The fracture in the direction parallel to the base of the prism is distinctly foliated, and the powder phosphoresces on burning coals.

The same granite contains well defined crystals of beryl, and here and there a small crystal of tourmaline.

*Andalusite.*—This mineral I found in a rolled mass of white quartz, in small imperfect four sided prisms, near Lancaster. The colour is a reddish brown.

*Spodumen.*—A notice of this mineral has lately been published in the Journal of the Academy of Nat. Sci. of Philadelphia. I have visited the locality at Sterling, and find it very abundant. The principal rock in which it occurs is a compound of quartz, mica and spodumen, weighing probably about thirty tons. It may be called spodumen rock.

*Cleavelandite* occurs in small quantity at Sterling.

J. W. W.

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*Inside view*

*Perkins' new Steam Engine.*

*Plate 3.*